GRAPHICS-ORIENTED BATTLEFIELD TRACKING SYSTEMS:
U.S. ARMY AND AIR FORCE INTEROPERABILITY

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Joint Planning Studies

by

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The United States Military employs Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) systems to increase a commander's ability to defeat a "hostile, thinking, and adaptive enemy" by enhancing battle command through information superiority. Joint doctrine asserts that information superiority is achieved using C4ISR systems to collect, process, and disseminate information. Additionally, the speed and efficiency with which this is accomplished enhances the Army warfighting functions and Air Force core functions through more precise knowledge of friendly unit locations. However, the assortment and non-uniformity of information technology can create greater complexity in an already complex environment. This thesis examines whether or not different graphics-oriented battlefield tracking systems, as employed by the Army and the Air Force at the operational and tactical levels during full spectrum operations, have a negative impact on joint situational awareness. The author also presents several considerations for the design, development, and employment of future systems. Understanding the history, demands, and challenges to joint interoperability allows military professionals to use current C4ISR systems effectively while considering the best approach for developing future programs.

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ABSTRACT

GRAPHICS-ORIENTED BATTLEFIELD TRACKING SYSTEMS: U.S. ARMY AND AIR FORCE INTEROPERABILITY, by MAJ Jay H. Anson, 149 pages.

The United States Military employs Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) systems to increase a commander's ability to defeat a "hostile, thinking, and adaptive enemy" by enhancing battle command through information superiority. Joint doctrine asserts that information superiority is achieved using C4ISR systems to collect, process, and disseminate information. Additionally, the speed and efficiency with which this is accomplished enhances the Army warfighting functions and Air Force core functions through more precise knowledge of friendly unit locations. However, the assortment and non-uniformity of information technology can create greater complexity in an already complex environment. This thesis examines whether or not different graphics-oriented battlefield tracking systems, as employed by the Army and the Air Force at the operational and tactical levels during full spectrum operations, have a negative impact on joint situational awareness. The author also presents several considerations for the design, development, and employment of future systems. Understanding the history, demands, and challenges to joint interoperability allows military professionals to use current C4ISR systems effectively while considering the best approach for developing future programs.

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ACRONYMS

ABCS	Army Battle Command System
C2	Command and Control
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
CAS	Close Air Support
CCA	Close Combat Aviation
CID	Combat Identification
CJCSI	Chairman of the Joint Chiefs of Staff Instruction
COP	Common Operational Picture
DOD	Department of Defense
FBCB2	Force XXI Battle Command Brigade and Below
GAO	General Accounting Office
GIG	Global Information Grid
MEDEVAC	Medical Evacuation
ONS	Operational Needs Statement
OSVRT	One System Remote Video Terminal
PPBE	Planning, Programming, Budgeting, and Execution
PPBS	Planning, Programming, and Budgeting System
RAF	Royal Air Force
SA	Situational Awareness
SOA	Service-Oriented Architecture
SU	Situational Understanding
TBMCS	Theater Battle Management Core System

UAS	Unmanned Aerial System
U.S.	United States

ILLUSTRATIONS

CHAPTER 1

INTRODUCTION

The United States Military employs a multitude of information technology suites and software programs comprising a wide variety of Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) systems throughout the four Service components. The purpose of these systems is to increase a commander's ability to defeat a "hostile, thinking, and adaptive enemy" by enhancing battle command through information superiority (Department of the Army 2008a, 5-2). Joint doctrine asserts that information superiority is achieved using C4ISR systems to collect, process, and disseminate information (Department of Defense 2010c, I-2). Additionally, the speed and efficiency with which this is accomplished enhances the Army warfighting functions and Air Force core functions through more precise knowledge of friendly unit locations. However, the assortment and non-uniformity of information technology can complicate information systems management, prevent information systems integration, and create greater complexity in an already complex environment.

The prevailing perception in many military circles and among information technology professionals is that such a wide variety of systems with varying degrees of interoperability has the potential to impede efficiency (Association of the United States Army 2009b, 2). The intent of this thesis is to determine whether the vast assortment of technology has a negative affect on joint interoperability. In doing so, the author looks at how military demand, interservice rivalry, organizational culture, loopholes in the acquisition process, and budget limitations have resulted in a wide variety of C4ISR

systems fielded. Also examined is the interoperability between Army and Air Force graphics-oriented battlefield tracking systems. The author compares Link 16, a component of the Air Force's Theater Battle Management Core System (TBMCS) program, and Force XXI Battle Command Brigade and Below (FBCB2), part of the Army Battle Command System (ABCS) program. To determine negative affects caused by interoperability issues, the research focuses on several cases of fratricide, collateral damage, and other types of incidents that the TBMCS and ABCS programs were designed to prevent.

Background

This thesis seeks to determine if the wide variety of Army and Air Force C4ISR systems has a negative affect on joint interoperability. Joint interoperability and the associated information technology facilitating it are essential for joint campaigns and operations at the operational and tactical levels to be successful (Department of Defense 2010a, III-7). To understand the background of these systems, it is necessary to discuss the Global Information Grid (GIG), the warrior component of the GIG and its associated services supporting joint force operations, and the development of applications such as the TBMCS and ABCS programs. Finally, the author takes a brief look at potential reasons why the Air Force and Army have gone their separate ways while pursuing information technology and briefly discuss the objectives of this research paper.

The GIG is a globally interconnected set of information capabilities. It includes the procedures and people that process, store, transmit, receive, and present information (Department of Defense 2010c, I-8). Included are the various networks at the strategic, operational, and tactical levels that interact with one another, providing connections to

both the United States (U.S.) information infrastructure and global communications networks. The GIG supports the Department of Defense (DOD) empowerment of joint forces by facilitating access to information (Department of Defense 2010c, x). Joint Publication 6-0, *Joint Communications Systems*, defines seven distinct components of the GIG. For the purposes of this chapter, the author discusses only the Warrior component, which constitutes those systems connecting the Warfighters and their combat platforms to the network.

Warrior component systems perform a wide variety of tasks including voice over internet protocol, email, internet access, intranet access, sharing of common operational pictures, and knowledge management (Department of Defense 2010c, A-2). Integrated communications capabilities facilitate unified action through coordinated intelligence, reconnaissance, and surveillance-gathering systems used to build a robust common operational picture. The establishment, sharing, and availability of the latest common operational picture improve the joint task force commander's ability to conduct joint operations. Much of the common operational picture piped into tactical operation centers and main command posts arrives in real-time or near real-time by way of graphics-oriented battlefield tracking systems. There are hundreds of applications used to control joint air operations, to synchronize land forces, and to develop a common operational picture of the battlespace. TBMCS and ABCS are the two programs containing battlefield-tracking applications currently used by the Air Force and Army, respectively (Department of Defense 2010c, II-8).

The TBMCS and ABCS programs provide commanders with better Situational Awareness (SA) and understanding of the battlefield. Lessons learned tracking friendly

and enemy forces manually during major operations following the Cold War, such as Operations Desert Storm in Iraq or Restore Hope in Somalia, resulted in a demand for more efficient tracking tools on the battlefield. For example, the technique of transmitting positional updates via frequency modulation radio to a tactical operation center where Soldiers updated those positions by hand on a map board proved inefficient during the Battle of Mogadishu (Baumann et-al. 2007, 151). Maintaining SA and understanding became extremely complex with multiple elements moving around the operational area to perform multiple tactical missions simultaneously. Looking back almost twenty years to when those operations took place, one can clearly see how current C4ISR assets would have alleviated the intense fog of war experienced by the commanders of the time. Fortunately for today's commanders, the lessons learned by those leaders and their recommendations were heeded. As a result, the military has been able to leverage technological advances such as improved satellite and digital data transmission technology to deliver ever-improving communications platforms.

The Air Force, along with the Navy and Marine Corps, uses the TBMCS while the Army employs ABCS (Department of Defense 2010c, II-7). The Services developed and fielded the programs in the early 1990s and both contain different software applications that are interoperable to some degree. TBMCS is an automated system used to develop, deconflict, disseminate, and execute air operations while managing collaborative targeting. Link 16 is the subsystem of TBMCS that provides graphics-oriented battlefield tracking capability in real time or near real time. The Army uses ABCS to automate battlefield tracking during joint operations. The software provided gives commanders the tools to more efficiently plan and synchronize the employment of

combat power (Department of Defense 2010c, II-9). The subsystem that facilitates graphics-oriented battlefield tracking in near real time is FBCB2.

The preceding paragraph begs the question as to why the Air Force and Army acquired two separate systems that have the same fundamental purpose. The Army is the only Service not using TBMCS (Department of Defense 2010c, II-9). Although interoperable to some degree, the potential exists that having multiple battlefield tracking systems employed by four diverse Service components that are incompatible, inefficient, or overly assorted could lead instead to fratricide, delayed close air support (CAS), or medical evacuation (MEDEVAC), loss or damage to equipment, degradation of mission capability, or, worst case, complete mission failure.

An organizational culture fostering interservice competition for funding and resources is one possible reason for the non-collaboration. An example of this is the Vietnam War and the Air Force's failed attempts to bring other Service's air power under the control of the tactical air control system (Horwood 2006, 79). More recently, an article titled "GAO: Army, Air Force Should Have Collaborated on UAVs" published in the 12 April 2010, editions of both the *Army Times* and *Air Force Times*, describes a costly turf war between the development of the Army and Air Force Unmanned Aerial System (UAS) programs (Spoth 2010, 21). The U.S. General Accounting Office (GAO) identified missed deadlines, performance shortfalls, and budget overruns. All seem avoidable had the two services cooperated on the effort. Rather than developing an Army Predator program and a separate Air Force Sky Warrior program, a single UAS program could have saved taxpayers over $3 billion. The UAS program is a stark example of interservice challenges that lead to stovepipes and duplication of effort.

This study also explores several other possible reasons. Shortfalls in training on the systems, either on-the-job or institutionally, prevents collaboration and Servicemembers from gaining the knowledge and proficiency to make the systems work together. To that end, joint doctrine acknowledges collaborative capabilities as an operational limitation (Department of Defense 2010c, III-21). Loopholes and flaws in the rules governing the acquisition process have allowed the funding and procurement of information technology programs that do not entirely meet the letter of the law in terms of compliance with DOD directives concerning interoperability requirements. Budget constraints have resulted in competing performance objective memoranda from Service Chiefs, combatant commander integrated priority lists, budgets, and the subjective interpretation of required military capability. Consequently, the Army and Air Force have fielded a wide variety of C4ISR systems with varying degrees of interoperability.

The overall objective of this study is to determine whether different graphics-oriented battlefield tracking systems employed during combat operations negatively affect SA and prevent the creation of a sufficient common operational picture between Army and Air Force units. Examples of negative impacts include instances of friendly fire incidents, fratricide, duplications of effort where common effort, or when better collaboration and SA could have prevented the incident. If the use of different battlefield tracking systems by the Army and Air Force is a barrier or hindrance to successful joint battlefield tracking, then a common system should be fielded that provides combatant commanders with the common operational picture and SA necessary to exercise command and control (C2) effectively. In order to reach a conclusion, this thesis focuses on three fundamental concerns.

First, the reasons for the existence of such a wide array graphics-oriented battlefield tracking systems employed by the Army and Air Force are studied. Logically, the need for information generated by these systems is the reason for their existence. There are potential reasons why the Air Force and Army have gone their separate ways while pursuing information technology. To that end, the second concern is identifying the challenges and obstacles to achieving and developing a truly joint system common to both Service components. These barriers to interoperability include funding issues, interservice rivalry, non-collaboration, and lack of training. Finally, the third concern of this study examines emerging technologies and possible applications to meet operational demands along with any initiatives and projects that promote joint interoperability.

The optimal and therefore most desirable situation is to have Army and Air Force elements depicted graphically, in real time, using interoperable systems that provide the commander with SA and understanding on as few screens as possible. The technology and architecture for this joint system should provide commanders and operators at all levels a common picture of every element of combat power in a given area. This study seeks to determine the reasons for the absence of such a system and whether this absence had negative effects on the ability of the Army and Air Force to work together efficiently during full spectrum operations.

Primary and Secondary Research Questions

In order to determine if the wide variety of information technology has a negative affect on joint interoperability, draw valid conclusions, and make credible recommendations, the author developed and answered several research questions. The primary research question of this paper asks:

If different graphics-oriented battlefield tracking systems, as employed by the Army and the Air Force at the operational and tactical levels in full spectrum operations, have a negative impact on joint SA, then what should be the considerations for the design, development, and employment of future systems?

To adequately address the primary research question, the author must first answer five secondary questions. These questions are:

1. What are the demands for graphics-oriented battlefield tracking systems? Are the Army and Air Force's needs similar?

2. Why are there different graphics-oriented battlefield tracking systems being employed by the Army and Air Force at the operational and tactical levels for SA during full spectrum operations?

3. Are there instances where having different systems negatively affected Army or Air Force operations (i.e. friendly fire, fratricide, duplication of effort)?

4. What are the challenges to developing and achieving a truly joint system for both the Army and Air Force (i.e. shortcomings in technology, military culture, funding, training, etc.)?

5. After examining current doctrine, reviewing relevant incidents and issues emerging from Iraq, Afghanistan, and other joint operations involving Army and Air Force elements, should either of the Services change its current methods of establishing SA through a common operational picture? If so, what emerging technologies or concepts can these Services apply to implement that change?

Definitions

The following list is a short glossary of key terms relevant to this study. The sources of these definitions include Joint, Air Force, and Army publications as well as online and traditional resources. The definitions contained herein aim at providing the reader a consolidated quick reference list for understanding the concepts and analysis presented in this paper. A brief discussion of each concept follows where necessary to eliminate ambiguity and vagueness in the doctrinal explanation, or to further clarify or expand upon the general definitions.

Battlefield Tracking System. These systems transmit and receive positional data via either satellite or terrestrial radio signals, periodically updating or refreshing positional data in real time or near real time (Miller 2006, 8). The systems use visual icons displayed on a digital map to depict actual geographic positions of friendly and enemy forces. Examples are the FBCB2 system used by the Army or the Link 16 system used by the Air Force.

Close Combat Aviation (CCA). The use of attack helicopter assets to provide direct fire support for ground forces (Department of the Army 2003a). CAS is also used to describe these actions. For example, Joint Publication 3-09.3, *Joint Tactics, Techniques, and Procedures for Close Air Support*, defines Joint CAS as being provided by both fixed-wing and rotary-wing aircraft in direct support of and in close proximity to ground forces. For the purpose of this study, the Air Force provides CAS while Army aviation provides CCA. The delineation is important to clarify between events involving only Army assets and joint events involving Army and Air Force assets. For example, an

operation where CAS arrived on station to engage targets in support of Army ground forces is clearly a joint operation.

Collateral Damage and Fratricide. As defined in Princeton University's Wordnet database: collateral damage refers to the inadvertent casualties and destruction inflicted on civilians in the course of military operations (Princeton University Wordnet 2010a). Fratricide is friendly fire that injures or kills an ally (Princeton University Wordnet 2010b).

Command and Control. The exercise of authority and direction by a properly designated commander over assigned and attached forces in the accomplishment of a mission. Commanders perform C2 functions through a C2 system (Department of Defense 2004b).

Command and Control Systems. The arrangement of personnel, information management, procedures, and equipment and facilities essential for the commander to conduct operations and establish a common operational picture (Department of the Army 2010b).

Commonality. A quality that applies to materiel or systems that either possess interchangeable characteristics that allow personnel trained on each of the other systems to install, operate, or maintain each other's systems; or allows for interchangeable parts and components between systems (Department of Defense 2004b).

Common Operational Picture (COP). An operational picture tailored to the user's requirements, based on common data and information shared by more than one command (Department of the Army 2008a).

Display. An information management activity: to represent relevant information in a useable, easily understood audio or visual form tailored to the needs of the user that conveys the common operational picture for decisionmaking and exercising C2 functions (Department of the Army 2003b).

Disseminate. An information management activity: to communicate relevant information of any kind from one person or place to another in a usable form by any means to improve understanding or govern action (Department of the Army 2003b).

Force XXI Battle Command Brigade and Below. FBCB2 is an integrated C4ISR system used to plan, execute, and track ground forces and close combat attack assets. It delivers standardized, secure, automated planning and execution tools for the Army, and gives commanders the tools to build and share an automated common operational picture (PM-FBCB2 Brigade Battle Command 2006). Unless stated otherwise for the purposes of this research paper, FBCB2 refers to all variations to include FBCB2 (Enhanced Position Location Reporting System Tactical Internet), FBCB2-Blue Force Tracker (L-Band Satellite Network), and Blue Force Tracker-Aviation (fixed-wing and rotary-wing aircraft systems).

Interoperability. The ability of systems, units, or forces to provide data, information, materiel, and services to and accept the same from other systems, units, or forces and to use the data, information, materiel, and services so exchanged to enable them to operate effectively together. Additionally, interoperability includes the technical exchange of information and the end-to-end operational effectiveness of that exchange of information as required for mission accomplishment. Interoperability is often incorrectly

used interchangeably with interdependence and integration (Department of Defense 2010c).

Interservice Rivalry. Rivalries that can arise between the various branches of a country's Armed Forces, such as a nation's land forces, naval forces, and air forces (Oxford Reference Online 2010).

Monitoring. The continuous observation of the common operational picture to identify indicators of opportunities for success, threats to the force, and gaps in information (Department of the Army 2003b).

Performance-Based Logistics. The Defense Acquisition Guidebook defines performance-based logistics as an affordable, integrated, performance-based package designed to optimize system readiness and meet performance goals for a weapon system through long-term support arrangements with clear lines of authority and responsibility (World Trade WT100 2008). Under performance-based logistics contracts, the manufacturer assumes most of the risk because system capability and level of performance is guaranteed. Rather than selling the system, repair parts, and expensive emergency technical services, the contract includes engineer support through out the entire life cycle of the system (Thuermer 2009).

Planning, Programming, Budgeting and Execution Process. The Acquisition Community Connection website defines this as the process for allocating resources within the DOD. The program is a cyclic process that provides the mechanisms for decision-making and provides the opportunity to reexamine prior decisions in light of changes in the environment. Those changes include but are not limited to evolving threat and changing economic conditions. The ultimate objective of the program is to provide

the Combatant Commanders with the best mix of forces, equipment, and support attainable within established fiscal constraints (Acquisition Community Connection n.d.).

Service-Oriented Architecture. Sentek Consulting, Inc. defines service-oriented architecture (SOA) as the grouping of functionality around business processes and packaging them as interoperable services. In the case of graphics-oriented battlefield tracking systems, SOA is the construct that allows these services to communicate with each other by creating a logical bridge for passing data (Matthews 2008).

Assumptions

The author maintained two assumptions while writing this paper. First, although there are numerous proposed programs and continuous upgrading of current systems, no "breakthrough" technology fielded in the next ten years will be 100 percent common to both the Army and Air Force. Therefore, a single-joint system is unlikely. Second, there will be no change in the military's planning, programming, budgeting and exception process during the same period. Consequently, the ability of the joint force to replace current systems wholesale is not plausible.

Limitations

Three important limitations affected the scope and depth of this study. First, this paper will not address classified information or information deemed as releasable "For Official Use Only" in order to allow for unlimited distribution. Moreover, the study will not include system operation in relation to classified techniques, tactics, and procedures used during recent combat operations in Iraq and Afghanistan. To a lesser degree, the author will avoid discussing any incompatibilities or shortcomings in system

functionality determined during the course of researching this topic that has the potential to compromise or violate operational security.

Secondly, the Army and Air Force use numerous systems in a C2 capacity. These systems include radios using frequency modulation, high frequency, and tactical satellite live video feeds from UAS's, classified Secure Internet Protocol Router Network, and Nonsecure Internet Protocol Router Network. There are also numerous SOA systems for planning and supporting combat operations, intelligence analysis and production, terrain analysis, meteorological monitoring, and targeting. These systems do not fall into the category of graphics-oriented battlefield tracking systems as defined by this thesis.

Finally, a number of Army and Air Force units still employ legacy systems lacking an automated refresh capability. Instead, operators receive updates from outside reporting sources and manually input or update friendly and enemy positions. Although these systems could still be classified as graphics-oriented battlefield tracking systems, due to time constraints and the scope of the topic question, only those newer systems used by the Army and Air Force specifically for tracking friendly and hostile forces graphically, and in real-time or near real-time, will be explored.

Delimitations

In addition to the limitations set forth in the preceding paragraphs, four delimitations apply. First, since the focus is on joint interoperability between the Army and Air Force, this study does not examine similar planning and tracking systems used by the U.S. Navy and U. S. Marine Corps such as Global Command and Control System-Maritime or Tactical Data Links. Exploring the systems of all four Services would exceed

the time allotted for this study. This thesis does not address C4ISR systems exclusive to the Navy and the Marine Corps.

Second, this study focuses on current graphics-oriented battlefield tracking systems. Technology used for information sharing, knowledge sharing, or group communication technology based on voice-over-internet-protocols will not be covered. Although classified as C4ISR systems, these platforms provide a limited perspective of the tools commanders use to develop SA. The research also centers on systems that constantly and automatically refresh the positions of friendly forces moving across the operational area. Programs used for information or knowledge sharing and group communication technology based on voice-over-internet-protocols normally disseminate information after the fact. This study focuses more on systems that provide real-time or near real-time battlefield tracking. Additionally, due to the uncertainty of the program's future in light of recent budget cuts and program cancellations, this research paper will not address any suite of communications systems associated with or formerly projected for release as part of the Future Combat Systems.

Third, the research paper examines only the battlefield tracking of Air Force fighter aircraft and not airlift. The exploration of both requires research that would exceed the time allotted to complete this study. The exploration of airlift tracking and associated case studies is not included. The selection of combat aircraft is based on the similarities between requirements for tracking fighter aircraft and ground forces during combat operations.

Finally, the author has exhausted all available means and made every attempt to use the latest information and doctrine covering emerging concepts and emerging

technology related to the subject of this study. For example, as recently as April 2010, there were new reports concerning the latest developments in Army FBCB2 and the Army and Air Force UAS programs (Association of the United States Army 2010a). The research process considered both reports and their implications during thesis analysis. However, due to the constantly changing world of information technology, the deadline of 1 May 2010 was the cutoff for the incorporation of new information.

Scope

The focus of this thesis is to determine if different graphics-oriented battlefield tracking systems, as employed by the Army and the Air Force at the operational and tactical levels in full spectrum operations, have a negative impact on joint SA. Therefore, the author limits the studies scope to only those Army and Air Force systems capable of tracking friendly and hostile forces graphically, in real-time or near real-time. Concordantly, procurement, budget, and acquisition systems discussed apply to the entire DOD. In the case of Service specific programs, only those that deal with Army and Air Force will be examined and discussed in this paper.

This study begins with the examination of the demands for graphics-oriented battlefield tracking systems and whether Army and Air Force needs are similar. The author then explores the reasons for the existence of so many graphics-oriented battlefield tracking systems followed by a study of potential instances where having diverse systems negatively impacted Army and Air Force operations. Cases of collateral damage, fratricide, and duplication of effort were examined to determine the causes of the incidents.

In those cases involving current overseas contingency operations, the author will analyze documented methods of establishing SA through a common operational picture and their effectiveness. For cases where methods applied were ineffective, the study will discuss emerging technologies or concepts that can effect desired modifications to current standard operating procedures or techniques, tactics, and procedures. Also covered in the way ahead are the challenges to developing a truly graphics-oriented battlefield tracking system for both the Army and Air Force. Subjects include shortfalls in technology, military culture, funding, and training challenges.

Significance of Thesis

In April 2010, General Hondo Campbell, Forces Command Commander, addressed the Atlanta Chapter of the Armed Forces Communications and Electronics Association regarding current tactical C2 initiatives. One of the key points of his presentation was "the transition to agile and unified communications with the goal of establishing a joint and combined warfighting capabilities oriented architecture" (Campbell 2010, 7). Clearly, there has been a noticeable shift even in military doctrine placing a greater emphasis on joint interdependence and joint interoperability. Joint Publication 1, Chapter 1 best describes the reason for this shift by stating, "The synergy that results from the operations of joint forces maximizes the capability of the force" (Department of Defense 2007b). Plainly stated, the more efficiently the Services are able to work together, the better the results.

This same topic is central to both the Army and Air Force strategic goals and visions. The *Army Vision 2010* as laid out by the Army Chief of Staff, General George W. Casey, emphasizes information superiority through better joint interoperability (Casey

2010, 3). Information superiority provides leaders with uninterrupted synthesis of combat power at the operational and tactical levels. The same priorities drive current Air Force strategy (Department of the Air Force 2006b, 10). The better fusion of intelligence and operations using communications technology allows commanders to produce action plans that are executable in real time. The overall subject of this thesis is central to achieving the desired level of synergy between the core competencies and inherent combat power of each Service component during joint operations. In order for joint campaigns and operations at the operational and tactical levels to be successful, joint C2 is vital.

Integrated communications capabilities facilitate unified action through coordinated intelligence, reconnaissance, and surveillance-gathering systems used to build a robust common operational picture (Department of Defense 2007c, III-7). Although somewhat limited in scope to only graphics-oriented battlefield tracking systems, the overarching theme of this thesis is significant and relevant to the future of the Armed Forces. According to the 2010 *Quadrennial Defense Review* (Gates 2010, 2) and the 2008 *National Defense Strategy* (Gates 2008, 19), current strategic defense goals focus not only on achieving joint interdependence and interoperability, but interagency and multinational sharing of information and information technology, as well. Before the joint services attempt to cross that bridge, a little house cleaning with the planning, programming, budgeting, and execution (PPBE) process is in order.

While studying the impacts of divergent systems between two Services, the study also explores the ways communications networks support and enhance the Army warfighting functions and Air Force core functions. The following chapters examine relatively modern concepts such as “thoughtware” (Stephenson 2006) as well as the

interaction between “data fusion” and “decision support” (Evrendilek et al. 1997). The paper looks at interoperability between Army and Air Force graphics-oriented battlefield tracking systems. The author examines current issues surrounding DOD procurement and acquisition processes and whether the systems support joint interoperability. As combat power continues to integrate the different Service components, the procurement and employment of either common or fully interoperable communications systems will become increasingly critical. The ability to do both will provide an integral element of truly successful joint interoperability. This thesis reinforces the importance and necessity of joint interoperability while exploring the impact of fielding, installing, operating, and maintaining multiple redundant systems.

CHAPTER 2

REVIEW OF LITERATURE

The research conducted focused on determining if the assortment of graphics-oriented battlefield tracking systems, as employed by the Army and the Air Force, has a negative impact on joint SA. A great deal of literature exists concerning C4ISR systems. Doctrine, service school publications, papers, and professional journals; literature from non-military research and development organizations; and historical documents, books, and articles were researched. This included a variety of documents pertaining to the Army and Air Force graphics-oriented battlefield tracking systems, the employment of those systems, and examples of their use during full spectrum operations. The information available allowed for a comprehensive, complete, and sufficient document analysis of a wide variety of topics related to C4ISR systems. Experts have written a great deal regarding emerging technology and emerging concepts. Program managers can certainly apply the new concepts and technology to the design, development, and employment of future systems. There are ample records regarding the demands for graphics oriented battlefield tracking systems by both the Army and Air Force, along with explanations as to why each Service employs separate systems.

Included in the collection of literature are enough instances of friendly fire, fratricide, and duplication of effort to determine whether or not having different systems negatively impacted Army and Air Force operations. Current doctrine, documents on relevant incidents and issues emerging from Iraq, Afghanistan, and other joint operations involving Army and Air Force elements, provide insight into the current methods of establishing SA through a common operational picture. The span and accuracy of the

material allows for a thorough analysis prior to recommending any changes. An ample record is available to determine which if any emerging technologies or concepts are applicable to implement change. Finally, the literature available references numerous challenges to developing a truly joint system for both the U.S. Army and U.S. Air Force.

The author thoroughly reviewed a large compilation of references from the Combined Arms Research Library filled with applicable literature. The abundance of material allowed for a comprehensive, complete and sufficient document analysis of a wide variety of topics related to C2 technology. The level and amount of material available was more than sufficient to conduct research on this topic. There were extensive collections of doctrine, technical manuals, field manuals, books, periodicals, and service school papers covering the topic of this thesis. The literature provided firsthand accounts, lessons learned, and after action reports from which answers were found for both the primary and secondary questions posed in this research paper.

Significant Literature

During the course of the research, several key sources provided a considerable amount of relevant information regarding not only graphics-oriented battlefield tracking systems, but also the applicability and use of the systems on the modern battlefield. Of intellectual importance was the analysis of two opposing academic positions on the subject of interoperability between C2 systems. For this study, the author selected two books, the *Encyclopedia of Computer Science and Technology* by Dr. Jack Belzer, Dr. Albert G. Holzman, and Dr. Allen Kent and *Planning and Architectural Design of Modern Command Control Communications* by A. Negat Ince, Cern Evrendilek, Dag

Wilhelmsen, and Fadil Gezer. Both provided definitions and concepts from academic authorities and were relevant to the subject matter of this thesis.

More noteworthy is that the books provide an analysis and diverging conclusions from two distinctly divergent points of view. A chapter by Dr. Victor H. Yngve in the *Encyclopedia of Computer Science and Technology* advocated the need for commonality in systems between Service components (Yngve 2000). Meanwhile, Ince, Evrendilek, Wilhelmsen, and Gezer offer that any the most diverse assortment of systems logically integrated into the C2 construct of the organization are acceptable (Evrendilek et al. 1997). In it, the authors discuss the importance of the interaction of two primary functions: data fusion and decision support as opposed to Dr. Yngve's support of systems commonality. Several paragraphs in chapter 4 further compare and contrast these two points of view.

Of doctrinal significance, Joint Publication 6-0 provides comprehensive doctrinal references and concepts for joint communication systems. Illustrations of joint operations involving Army and Air Force elements were paramount to the successful analysis of the topic and completion of this paper. However, most noteworthy of these were the *Multi-service Tactics, Techniques, and Procedures* documents published by the Air Land Sea Application center in Langley, Virginia. These manuals consolidate doctrine from all four Service components into one consolidated source document covering topics such as Joint Fires, Joint Surveillance Target Attack Radar Screen employment, and Joint Air Traffic Control. These publications provided a practical means of evaluating and studying doctrinal procedures more efficiently. Information on the interaction of different C2 systems between the Army and Air Force was readily available while directing the author

to the specific Service's doctrine that covers the topic under review. In total, these resources supplied a wealth of useful information covering a wide range of topics suitable for this study.

Doctrine and Technical Manuals

Joint Publications, Army Field Manuals, and Air Force Doctrine Documents were all reviewed for pertinent information on joint interoperability. Examples of doctrine related to the thesis topic include Joint Publication 3-09.3, *Joint Tactics, Techniques, and Procedures for Close Air Support*; Field Manual 3-52, *Army Airspace Command and Control in Combat Zones*; and Air Force Doctrine Document 2-8, *Command and Control*. In addition to regulatory guidance, technical manuals such as the Army Battle Command System User Tool Box, the Force XXI Battle Command and Below program of instruction provided considerable information on the background of existing graphics-oriented battlefield tracking systems.

Service School Publications, Papers, and Professional Journals

The National, Navy, Army, and Air War Colleges and the School of Advanced Military Science have published a number of related monographs. These papers are supplemented by several theses published by Masters in Military Art and Science graduates from the U.S. Army Command and General Staff College. For example, a paper written by Major James P. Meger titled "The Rise of the Unmanned Aerial Vehicle and its Effect on Manned Tactical Aviation" provides an interesting perspective on the impact of emerging technology on other warfighting functions and discusses the challenges posed by the potential for saturation of airspace C2 systems (Meger 2006).

Professional journals including *Military Review*, *Defense Report*, *Defense Daily*, and the *Army Times* encompassed a diverse collection of opinions and analyses of commonly known issues with joint interoperability such as finding time for joint exercises and other barriers to joint cooperation. Also valuable to the research were trip reports, briefings, and other material from the Joint Warfighting Center in Nellis Air Force Base, Nevada. These documents provided information regarding ongoing training programs, initiatives and issues compiled from major training centers and ongoing operations in Iraq and Afghanistan. These resources provided background information on the systems as well as recent challenges, emerging concepts and technology relevant to the thesis focus. Lastly, the viewpoints from a variety of authors provided the foundation for identifying trends and gaps in the literature for the purpose of this study.

Non-Military Research and Development Organizations

Additional searches of non-military research and development organizations revealed a large amount of documents related to this thesis. Several groups, including the RAND Corporation, the Combat Studies Institute, and the Association of the United States Army Institute of Land Warfare, have conducted independent studies in the areas of improved joint interoperability, predominantly between the Air Force and Army. Of note was a recent study conducted by the RAND Corporation concerning the possibility of enhanced fires and maneuver capability through greater interoperability between available combat power in the air and on the ground (Comanor et al. 2009, 76).

Based on extensive research, the authors recommend that air power be integrated across all military operations as opposed to the current method of deconflict and parse out the capabilities. Government contracted firms such as General Dynamics and other

civilian contracted or DOD civilian teams have also provided a wealth of documents for review such as the Transition Integrated Product Team (Army) currently fielding the Combined Enterprise Regional Information Exchange System International Security Assistance Force network software and associated systems in Afghanistan. These organizations were an important source of current information on the demands and challenges associated with joint interoperability. The literature produced also covered in detail emerging technology and concepts for improving joint interoperability between the Army and Air Force.

Historical Documents, Books, and Articles

The historical documents, books, and other articles gathered by the author focused on the background, demands, challenges, and emerging technology applicable to the thesis topic. There were literally hundreds of documents and articles covering C2 issues, especially the importance of effectively leveraging technology to enhance the military's ability to fight and win on the modern battlefield. These documents also focused on graphics-oriented battlefield tracking systems, the employment of these systems by the Army and the Air Force, case studies of joint collaboration at the operational and tactical level in full spectrum operations including cases of collateral damage, fratricide, and duplication of effort. Also covered were the design, development, and employment of future systems. These documents complemented the other significant literature outlined in the preceding paragraphs by providing extensive background information on the concepts and technologies associated with joint operations, while increasing the range of subject matter available for analysis.

Analysis of Literature

Overall, a sufficient quantity of literature exists concerning C2 systems. The quality of the literature varies from service school publications, professional journals and non-military research and development organizations' research papers, to the brief reports and clips of information provided by essays and news articles. Throughout this broad spectrum of information, one can find a satisfactory variety of documents pertaining to the Army and Air Force graphics-oriented battlefield tracking systems, the employment of those systems, and examples of their use during full spectrum operations. Through careful analysis using the research methodology outlined in the next chapter, one can reach a conclusion as to the negative impact that different graphics-oriented battlefield tracking systems, as employed by the Army and the Air Force at the operational and tactical level in full spectrum operations, have on joint SA.

Gaps in the Record

There are doctrinal and conceptual gaps within the available literature covering the topic of this thesis. Despite a great deal of emerging technology, the mainstream media has failed to report on the success stories of information technology initiatives. Military and civilian organizations that produce the equipment have not promoted organizational awareness touting the interoperability capabilities in existing systems, nor does any type of strategic communications plan appear to exist. There is little to no reporting in the mainstream media on the availability of training programs or the way the training can facilitate interoperability among the two Service's C4ISR systems. Similarly, there is no documentation clearly identifying a definite failure in joint interoperability between the Army and Air Force due to different graphics-oriented battle tracking

systems. Finally, there is no real discussion of the importance of an Army and Air Force common operational picture or the means to achieve one.

Trends

Based on a review of the literature available, five distinct patterns emerged. First, program managers base the development of C4ISR systems on the constant demand for better, more relevant systems. Secondly, the requirement for a joint interoperable air and ground system dates to 1993. The past decade and a half has seen the introduction and fielding of numerous communications platforms referred to as joint systems while being used by only one Service component. Next, there were several indications of a possible connection between shortcomings in graphics-oriented battlefield tracking systems and incidents of fratricide, inadequate SA, or unnecessary collateral damage. Fourth, there are several examples of interservice rivalry, non-collaboration, and duplication of effort that have caused severe fielding setbacks and wasted time and money on development. Finally, there is no shortage of proposed technology, emerging technology, and emerging concepts regarding information systems.

Commanders want better C4ISR systems. The majority of the articles found in the variety of periodicals examined, address a demand for better, more relevant C4ISR systems by leaders at all levels, from the combatant level to company command. There were several challenges faced by the information technology professionals striving to meet those demands. The predominant issues revolve around doctrine, lack of training time, and military culture, a lack of interconnectivity between Service component systems, and the systems in and of themselves. For example, the Army employs the ABCS's while the Air Force uses the TBMCS's. Both serve the same purpose of

providing graphics-oriented battle tracking functions; however, the ABCS's and TBMCS's are not fully interconnected.

The second rather disturbing pattern is the existence of documentation identifying a requirement for a joint interoperable air and ground system dating to 1993. In fact, one cannot differentiate between an article written ten years ago and one written yesterday simply by looking at the title. The technology under discussion along with the date of the article may have changed, but the theme remains the same. For example, "Work Begins on Military's First Joint Communications System" is a *C4I News* article dated 16 March 1995. A similar *GAO Reports* article, "Radio Communications: Congressional Action Needed to Ensure Agencies Collaborate to Develop a Joint Solution" was published over a decade later on 12 December 2008. Clearly, the military is not dealing with a new issue in attempting to develop joint interoperable, graphics-oriented battle tracking systems.

Furthermore, the term "joint" as used in the numerous articles and documents reviewed for this thesis superficially addressed the concept. Numerous systems, including the Army's Joint Network Node or the Air Force's Joint Surveillance and Target Attack Radar System, were joint in name only. Rather than being a joint platform, these systems were Service specific and usually performed a limited role in supporting that individual Service's ability to perform its core competency.

Third, in terms of negative impacts caused by the disparity in Service component technology, some sources indicated a connection between shortcomings in graphics-oriented battlefield tracking systems and incidents of fratricide, inadequate SA, or unnecessary collateral damage. A closer examination of these events was essential to determine if the incidents in question were valid instances of graphics-oriented battle

tracking incompatibility or caused by other factors such as equipment malfunction or human error. As would be expected, Operations Iraqi Freedom and Enduring Freedom provided several recent examples of doctrinal and technological issues with air and ground force integration.

Fourth, many of these recent issues mirrored similar problems faced during earlier operations such as the setbacks caused by interservice rivalry between the Army and Air Force during the Vietnam War. In fact, the article "GAO: Army, Air Force Should Have Collaborated on UAVs" published in the 12 April 2010, editions of the *Army Times* and *Air Force Times*, describes a costly turf war between the development of the Army and Air Force UAS programs (Spoth 2010, 21). The U.S. GAO identified missed deadlines, performance shortfalls, and budget overruns. All seem avoidable had the two Services cooperated on the effort. Rather than developing an Army Predator program and a separate Air Force Sky Warrior program, the GAO estimated that the DOD could have saved taxpayers over $3 billion by investing in a single UAS program (Spoth 2010, 21). The UAS program is a stark example of non-collaboration that leads to stovepipes and duplication of effort.

The GAO's report and ensuing critique outlined above was in stark contrast to a 2006 *Defense Daily* article published at the onset of the Army's and Air Force's development of the UAS programs (Roosevelt 2006). The article touts "platform commonality" and "interoperability" as the "focal point of much effort." In reality, although the platforms were definitely similar, for reasons not covered in the article, the Air Force and Army did not collaborate on the actual acquisition process. This type of

occurrence is indicative of the interservice barriers, especially when competing for funds, still existing between the Army and Air Force.

Another example illustrated non-collaboration during ongoing overseas contingency operations. The February 2010 *Time Magazine* article, “The Survivor” describes several of the challenges faced by current Secretary of Defense Robert M. Gates in increasing joint interoperability (Rubin 2010, 29). The author recounts how Secretary Gates had to step in to get Air Force officials in Afghanistan to reallocate search and rescue helicopters for MEDEVAC missions.

Finally, as far as existing literature is concerned, ample documentation is available regarding emerging technology and emerging concepts geared towards overcoming technological shortcomings. However, in light of current budgetary constraints, the trends identified focus on improving, upgrading, or sustaining existing systems only. What all of the authors definitely did agree on was an existing demand for joint interoperability and information technology that satisfies those requirements.

Significance of Thesis in Relation to Existing Literature

In examining graphics-oriented battlefield tracking systems and the possible impacts of simultaneously employing the different Army and Air Force systems, this paper contributes to the ever-expanding body of academic work related to joint operations in four ways. First, it looks at the demands and challenges involved in developing joint C4ISR system technology in the context of the rising emphasis on joint interoperability. Next, the study documents and examines the potential dangers and pitfalls inherent in failing to employ interoperable technology among Service components during full spectrum operations. Third, in Chapter 5, “Conclusions and

Recommendations," the author looks at a number of emerging technologies and suggests several options for improving current C4ISR. Finally, the author compares two predominant schools of thought regarding the most efficient approach to interoperability. This examination brings to light several key points that commanders and information technology professionals can consider when planning, developing, and employing future systems.

This thesis defines the major demands and barriers to interoperable graphics-oriented battlefield tracking systems. Bringing these into perspective demonstrates how the Army and Air Force have collaborated and highlights the challenges both Services have faced. This paper discusses the acquisition process and the setbacks, waste, and friction caused by competing Service component budgets or lack of collaboration. Also discussed are the limitations of existing technology due to training shortfalls and interconnectivity issues.

Next, the author examined potential dangers and pitfalls such as fratricide or collateral damage during joint operations where C4ISR shortcomings were involved. Deficiencies in joint interoperability were found, but predominantly, there were several other major contributing factors other than technology in the cases examined. Academically, the analysis of a procedural versus a commonality approach to joint interoperability in chapter 4 provides considerations for employing current C4ISR systems. These considerations are also applicable to shaping the best use and direction for emerging technology. The emerging technologies covered in the final chapter provide an overview of those systems and concepts in development. Provided with the brief summary of each system are recommendations for their applicability during full spectrum

operations. The overall intent of this document is to provide a record from which decision makers can draw concepts and ideas when developing the way ahead for joint operations.

CHAPTER 3

RESEARCH METHODOLOGY

The purpose of this study dictated the research focus primarily on determining negative impacts on joint SA between the Army and Air Force due to the divergent C4ISR systems during full spectrum operations. This chapter details the steps taken to obtain the information needed to make that determination. The literature available dealing with the thesis topic was extensive and varied in scope and depth. To keep the amount of gathered material manageable and relevant, the author applied several criteria when selecting information for analysis. At the conclusion of this chapter, the author outlines the strengths and weaknesses of the research methodology applied.

Steps Taken to Obtain Information

The research involved five methods used to search for and obtain material for this study. Initial inquiries covered all sources available through the Combined Arms Research Library at Fort Leavenworth. The next source of information for doctrine and technical manuals was the United Sates Army Publishing Agency website. A third source of information came from personal searches conducted of the various websites and databases of private organizations such as the RAND Corporation, GAO Reports, or *Defense Daily*. Next, a rapport was established with several members of Transition Integrated Product Teams, TRADOC Capability Managers, and the Army Joint Support Team yielding valuable team documents and unclassified executive summaries. Finally, several agencies at Fort Leavenworth, Kansas, publish and distribute a number of military

periodicals and publications summarizing the employment of current techniques, tactics, and procedures in the joint operational environment.

A search conducted by the Combined Arms Research Library's reference section generated hundreds of results. Of particular value were documents containing experiences or accounts from Operation Enduring Freedom and Operation Iraqi Freedom. The search also yielded a number of relevant books, monographs, and theses from previous Masters in Military Art and Science graduates. Much of the literature provided by the library covered numerous joint operations and training exercises involving simultaneous C2 of Army and Air Force elements. The author selected key documents from the search results for further study and analysis then used the results to answer the primary and secondary thesis questions.

Of equal importance was the exploration of relevant military publications in both hard copy and digital format from the Army Publishing Directorate's website. The purpose of these official documents was to gain both an overview and regulatory guidance on the employment of joint communications systems. Follow-on research into the content of technical manuals and doctrine involved consulting with members of different departments of the U.S. Army's Command and General Staff School. Clarification from members of the Joint, Interagency, and Multinational Operations and the Digital Leader Development Center departments, both located at Fort Leavenworth, Kansas, enabled greater insight into the subject.

As a third source of information, database searches of private research institutes and academic organizations were completed. The intent of selecting this source was to

review and consider research results from academic and industry authorities on the thesis topic. Nonmilitary points of view decrease the probability of bias in the research results.

Next, the author frequently requested and received information from Army and Air Force Transition Integrated Product Teams, TRADOC Capability Managers, Transition Integration Product Teams, and the Deputy Director of the Army Joint Support Team at Eglin Air Force Base in Florida. The materials included unclassified inter-departmental emails, executive summaries, sample standard operating procedures, and slide presentations featuring ongoing initiatives for improved information sharing between the target services.

To round out the research, the author accumulated and analyzed products from the various institutes on Fort Leavenworth. The collection includes literature from the Center for Army Lessons Learned, the Combined Arms Center, and the Combat Studies Institute. The research here concentrated on determining current demands from the field, the opinions of military academic authorities, and analyzing after action reviews and lessons learned from cases of fratricide or collateral damage.

The study carefully screened all research material and determined the significance of the information gathered. Answers to the primary and secondary research questions were drawn from further analysis of material meeting the research criteria below. The results of the analysis are available in chapter 4, while chapter 2, the literature review, discusses trends or gaps in the literature, along with any inherent implications.

Research Criteria and Sequential Analysis

As described in the literature review, the initial collection of literature assembled was extensive and required further evaluation. Criteria used for the screening focused on

how best to answer the secondary questions, which in turn would answer the primary question. Two additional criteria were applied to the research overall. Additionally, in analyzing the material and answering the primary and secondary questions, the order of the secondary questions was adjusted in order to facilitate a sequential analysis. The result was that each question fed into the next, complimented the thesis as a whole, and ultimately answered the primary question.

For the first secondary question, the research focused on determining the demands for graphics-oriented battlefield tracking systems and any similarities between the Army and Air Force's needs. The criteria applied here was to select literature containing doctrinal and historical facts related to each Service's requirements for graphics-oriented battlefield tracking systems. An analysis of the research material explaining the numerous demands for ABCS and TBMCS revealed several reasons why the Army and Air Force went their separate ways to acquire these systems. Interservice rivalry, U.S. Code, Title 10 responsibility, and the existing stovepipe acquisition process were contributing factors that led directly to secondary question number two.

The next question sought to determine the reason for the different graphics-oriented battlefield tracking systems employed by the Army and Air Force. For that purpose, two research criteria applied. Information gathered centered on interoperability policies that apply to the DOD's acquisition procedures and historical references to the initial development of both the ABCS and TBMCS programs. The interoperability policies and study of the acquisition process demonstrated that there were several formidable challenges to achieving joint interoperability.

In terms of answering the primary question, the third question carries significant weight. Therefore, the screening criteria were much more stringent. In examining instances such as friendly fire, fratricide, and collateral damage, where using dissimilar Army and Air Force systems potentially affected joint operations negatively, two criteria apply. First, the incident had to involve personnel and equipment of both Services. Second, a lack of joint interoperability includes human error as well as equipment failure. Therefore, incidents involving both were examined. The finding was that interconnectivity issues did not cause adverse incidents. Instead, shortfalls in training were the primary cause. This helped to answer both the last secondary question and the primary thesis question.

To answer the fourth question, the author explored the challenges to developing and achieving a truly joint system for both the Army and Air Force. The research conducted for this area initially centered on literature related to shortcomings in technology. However, other contributing factors such as training deficiencies, funding, and non-collaboration emerged. These areas required further research and expanded the scope of the question. To further validate and support these findings a case study analysis was in order. The case study analyses were also used to answer the fourth secondary question regarding whether or not diverse systems contributed to adverse incidents. The author examined several cases involving joint operations, to include incidents of fratricide and collateral damage.

For the last secondary question, deciding if the Army or Air Force should change its current methods of establishing SA through a common operational picture required two criteria to define effectiveness. The first is to gauge the efficiency with which

commanders can receive information using the information systems pertaining to each case study, internalize data, and apply it to battle command and operational design. This criterion focused on data filtering and delivery to the commander. The other criterion was the speed with which commanders can disseminate information to subordinates and leaders, to include procedures, transmission mediums, and training for personnel.

Finally, two overarching research criteria were applied. First, recent literature was pursued regarding the research topic. This is due to the frequently changing nature of information technology. The aim of the author was to present the most relevant research paper possible. Therefore, the more current the information, the more relevant it was for an effective analysis while strengthening the validity of any resulting recommendations and conclusions. In essence, the author explored both the doctrinal roles of C4ISR systems as used by commanders at the operational and tactical levels, in concert with the performance of operators in the air and on the ground. The purpose of examining these areas was to determine if there is sufficient interconnectivity for sharing and developing a Common Operational Picture (COP) between Army and Air Force elements.

As described in detail above, each of the five secondary questions effectively compliment and support one another. Ultimately, the analysis of the material conducted while researching the five secondary questions resulted in an answer to the primary question. In addition to answering the five secondary questions and the primary question, the criteria of the analysis and mental roadmap also facilitated the development of the conclusions and recommendations set forth in chapter 5.

Strengths and Weaknesses of Methodology

The strength of this research is in its systematic approach to gathering information. The author focuses on the background, demands, challenges, and emerging technology and concepts related to graphics-oriented battlefield tracking systems. Finally, conducting a descriptive study using a combination of military doctrine, academic studies, case studies, and historical documents and articles ensured a well-rounded study that sought to encompass as many points of view on the subject as possible. Especially compelling were the recent case studies involving C2 systems and the examination of joint doctrine and multi-service techniques, tactics, and procedures.

The weaknesses lie in the nature and scope of the study. It was impossible to consider and include all case studies, doctrine, and publications covering techniques, tactics, and procedures for joint interoperability. The author has chosen the few pieces of literature deemed to best represent the operation or employment of graphics-oriented battlefield tracking systems based on the research criteria. In doing so, this paper omits the information and findings of other cases. Finally, due to the security classification of current techniques, tactics, and procedures, the study focused heavily on doctrine, unclassified articles, reports from mainstream media, and military periodicals. Based on the limitations of the material collected, some conclusions and recommendations drawn from the analysis may not be as comprehensive due to the exclusion of certain procedural or technological improvements.

CHAPTER 4

ANALYSIS

Joint doctrine tells us that information superiority is achieved using C4ISR systems to collect, process, and disseminate information (Department of Defense 2010c, I-2). The Army and Air Force employ graphics-oriented battlefield tracking systems to achieve information dominance, SA, and Situational Understanding (SU). These three basic requirements have always driven the development, acquisition, and employment of these systems (Wass de Czege 2010, 25). The ABCS and TBMCS programs enhance the Army and Air Force's abilities to perform their warfighting functions and core functions, respectively. However, a prevailing perception in many military circles and among information technology professionals is that such a wide variety of systems with varying degrees of interoperability has the potential to hamper efficiency (Association of the United States Army 2009b).

This thesis examines the possibility that such a vast assortment of technology impairs joint interoperability. In order to answer the primary and secondary questions of this research paper, an analysis of acquisition, employment, and interoperability between Army and Air Force graphics-oriented battlefield tracking systems is needed. This chapter is organized to serve that purpose. Chapter 4 seeks to determine if the different graphics-oriented battlefield tracking systems, as employed by the Army and the Air Force at the operational and tactical levels in full spectrum operations, have a negative impact on joint SA. Following this analysis, considerations for the design, development, and employment of future systems are offered in chapter 5.

Harnessing the Global Information Grid

The first secondary question required research and analysis of Army and Air Force demands for graphics-oriented battlefield tracking systems. The thesis analysis will illustrate that, despite unique core missions and doctrinally diverse methods of accomplishing their missions, Army and Air Force demands for graphics-oriented battlefield tracking systems are fundamentally similar even though the specific system requirements are not. Overall, the aim was to leverage the most recent information technology to enhance the commander's capability for gaining SU and making decisions through improved SA (Ackerman 2005). The author reached this conclusion after careful examination of literature containing doctrinal and historical facts related to each Service's requirements.

In the 2010 *Quadrennial Defense Review*, Secretary of Defense Robert M. Gates identified the ability to "operate effectively in cyberspace" as one of the DOD's six key missions (Gates 2010, 19). The demand for technological tools that give the military the best resources to defend the nation has been a requirement of almost every national defense and military review since the Goldwater-Nichols Act mandated such reports in 1986. At the highest levels of government, investing in the right kinds of technology at the right time has been a top priority (Gates 2008, 20). Achieving decision superiority, the process of making decisions better and faster than an adversary, is essential to executing military operations based on speed and flexibility (Myers 2004, 19). Harnessing and leveraging technology received increased attention following the fall of the Soviet Union and victory during Desert Storm (Department of Defense 1991, 27).

During subsequent reviews of national security and military strategies, the importance of maintaining and building on the technological edge that gave the U.S. such a distinct advantage in the Persian Gulf was prominently mentioned (Shalikasvili 1995). Even in those early years, the nation's military leaders recognized the strategic implications and applicability of the internet while it was still an emerging technology. Victory in future conflicts would be dependent on winning what was referred to at the time as the "information war." Therefore, the "leverage attainable from reconnaissance, intelligence collection and analysis, and high-speed data processing" warranted special attention (Shalikasvili 1997).

In order to exploit the advantages from Desert Storm, there was growing demand for a global C2 system engineered for joint and multinational interoperability. The Army and Air Force set out to acquire the systems that would help them meet the mandate of the Chairman of the Joint Chiefs of Staff and the Secretary of Defense to "harness the GIG" (Myers 2004, 25). Although the demands were the same for both the Army and the Air Force, both Services went their separate ways to acquire a system of systems to meet those demands. The reason for the divisiveness was twofold.

First, the technological requirements for tracking air and ground forces were very different. Tracking ground forces is essentially a two dimensional process requiring calculations based on a friendly element's position relevant to known geographic references as depicted on a map. The Army warfighting functions, or battle operating systems as they were known at the time, required assorted methods of coordination and calculation to request and deliver ground-based fires, transmit battle damage assessments, and spot reports. Meanwhile, the addition of altitude made tracking aircraft a more

complex three-dimensional process. Therefore, the Air Force needed different tracking software from what the Army was developing. Furthermore, the procedures for airspace deconfliction, planning air interdiction, processing requests for CAS, and generating Air Tasking Orders required software unique to these and other core functions. In essence, two separate systems were needed.

Second, despite the requirements for joint collaboration dictated by Goldwater-Nichols when then President Ronald Reagan signed it into law in 1986, there was little to no emphasis or oversight in place to ensure joint considerations during the early 1990s (Wilson 2002, 6). The emphasis on joint interdependence did not exist as it does today. The Services, however, still had the U.S. Code Title 10 requirement set forth in Section 3062 to “train, equip, and organize forces for prompt and sustained combat” (U.S. Congress 1979). Therefore, the only option at the time was to move forward with research and development for C2 technology with limited joint collaboration. As depicted in figure 1, the result was the stovepipe development, acquisition, and fielding of the TBMCS and ABCS programs.

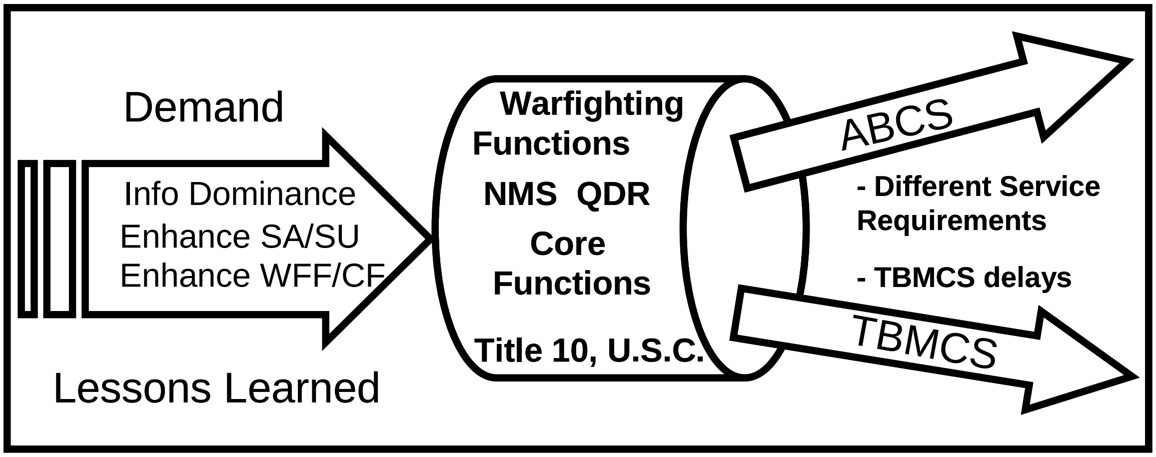

Figure 1. TBMCS and ABCS Development
Source: Created by author based on information from Huba Wass de Czege, "NETWAR: Winning in the Cyberelectromagnetic Dimension," *Military Review* (March-April 2010): 20-32.

The ABCS and TBMCS Stovepipes

Examining each system independently illustrates both the different requirements of each Service and the similar demands. This includes the graphics-oriented battlefield tracking systems associated with each. First, a brief history and status of the Air Force TBMCS program is looked at along with the aircraft tracking system, Link 16. The past, current, and future status of the Army's ABCS is then studied to include, FBCB2, the system for tracking ground forces.

TBMCS is an integrated air C4ISR system used to plan and execute air battle management. It delivers standardized, secure, automated air battle planning and execution for the Air Force, and includes a common operational picture. The operational concept for TBMCS originated circa 1995. DOD developed the system in response to user demand for a more streamlined process of generating the Air Tasking Order based on lessons learned from Operation Desert Storm (Collens and Krause 2007, 2). The Air

Force contracted Lockheed Martin, Incorporated, to provide a system commanders could use to plan, direct, and control theater air operations, while simultaneously coordinating with land, maritime, and special operations forces. The resulting robust and versatile suite of hardware, software, communications links, spares, personnel, training, and other resources took five years to develop, from 1995 to 2000 (Krause 2005, 8).

The reason for the extensive acquisition and development process was due to the complexity of the TBMCS program. TBMCS was originally intended to satisfy Air Force joint and multinational air battle tracking requirements (Collens and Krause 2007, 8). The system requirements and technical specifications were incredibly advanced and highly customized. Without a preexisting architecture, systems engineers were unable to develop a viable performance baseline as a starting point for the program. However, this proved easier said than done. The added complexity of integrating both commercial-off-the-shelf software and the three Air Force legacy systems: Contingency Theater Automated Planning System, the Wing Command and Control System, and the Combat Intelligence System, led to numerous delays. The conglomeration of different software vendors such as Oracle, UNIX, Sun Microsystems, and Hewlett Packard contributing to the system and subsystem design caused the process to be somewhat disjointed. These issues coupled with the inability of engineers to test their product in the field resulted in TBMCS failing its first operational test (Collens 2005, 3).

As a result, the system engineers regrouped and established a workable and achievable baseline based on the functionality provided by the existing legacy systems. This led to a revised system design that only satisfied air battle requirements. The inaugural version of TBMCS was able to nominate and prioritize air targets, plan and

disseminate the daily air battle plan, receive and analyze the air battle plan, plan a detailed flying schedule within four hours, and monitor and control the execution of the air battle plan. Up until DOD fielded the third version of TBMCS, there was very little battle tracking, and the interfaces needed to share data with ABCS were not present (Collens 2005, 18).

The latest version of TBMCS implements interoperable functionality with other C4ISR systems to effectively service targets. Due to the extreme complexity, systems engineers designed and built the original version to integrate only legacy Air Force systems. TBMCS is now comprised of 76 different applications, 413 segments, 5 million lines of software programming, and 64 point-to-point external interfaces for information sharing and battle tracking with the systems of all Services (Collens and Krause 2007, 3).

The graphics-oriented battlefield tracking system that interfaces with TBMCS is Link 16 (Vego 2008, 64). Link 16 comes in a reduced-size terminal small enough to fit inside of fighter aircraft and provides battle tracking for friendly ground, sea, and air assets. Link 16 brings a modern, complex, and high-capacity tactical data link that can be used for anti-air, air-to-air, and air-to-ground warfare. Along with being implemented onboard a U.S. Air Force fighter aircraft, the number of NATO ships and aircraft outfitted with Link 16 has steadily increased over the last decade (Ooms 2004, 20). Link 16 uses both satellite communications and line-of-sight via high frequency radio waves to update location and position of friendly forces. The aircraft control feature broadcasts pilot symbology to multiple aircraft simultaneously, further enhancing fighter lethality during air-to-air engagements (Vego 2008, 62). Not limited solely to symbology, Link 16 can also exchange surveillance data, electronic warfare data, mission tasking, weapons

assignment, and control data. The variety of systems is fully integrated to provide continuously updated C2 data, target sharing, and navigation data. The system can also be used for voice communications.

Since it reached the field in October 2000, TBMCS has performed exceptionally well (Krause 2005, 36). For example, during Operation Iraqi Freedom, the Joint Forces Air Comment Command used TBMCS to successfully plan, manage, and execute the Air Battle Plan whereby the Air Tasking Orders produced, exceeded the expected system parameters. Although predominantly viewed as an Air Force system, the DOD developed TBMCS based on multi-service requirements and it is actually used by three of the four Services. The Army is the only service that employs ABCS and not TBMCS (Department of Defense 2010c, III-7).

The demand for ABCS was derived from the lessons learned while tracking both friendly and enemy forces during both Operations Desert Storm in Kuwait and Restore Hope in Somalia. Not only did the key battles of these operations show the difficulty in using only radios to C2 a large force (Baumann et al. 2007, 151), they also demonstrated the importance of being able to develop and share a COP. During the Battle of Mogadishu, for example, the Joint Operation Center had immediate access to the highest quality satellite imagery and the latest C4ISR technology (DeLong and Tuckey 1993, 35). However, the commander was not able to share that information with the Delta Force and 75th Ranger Regiment convoy, the 10th Mountain Division Quick Reaction Force, or the numerous 160th Special Operations Aviation Regiment aircraft flying overhead (Bowden 1999, 136).

Military historians often refer to the 1991 Gulf War as the first “Electronic War” due to the inaugural use of wide area networks during combat operations (Freedman and Karsh 1993, 429). Nevertheless, despite giving the U.S. an overwhelming advantage over Iraqi forces, it still took hours to relay tactical and operational updates across the battlefield and to rear echelon commanders (Powell 1995, 508). The networking equipment employed, Mobile Subscriber Equipment, was a threat-based capability built for a linear war. System engineers designed Mobile Subscriber Equipment to provide communications in support of the defense of Germany and Western Europe from the Soviet Union at the Fulda Gap or South Korea from an invasion by North Korea (Quinn 1996, 52). It was extremely difficult to tear down, move, and reengineer quickly enough to support major combat operations in a more fluid and fast-paced arena (McGrath 2006, 217). From this analysis, any new equipment acquired by the military had to support what is now referred to doctrinally as full spectrum operations. This ranged from the high-speed, kinetic war in the vast and open desert battlespace of Desert Storm, the urban battlefield of Mogadishu, and the linear battlefield between North and South Korea. To meet these demands, the Army developed ABCS.

ABCS is an integrated C4ISR system used to plan, execute, and track ground forces and CCA. It delivers standardized, secure, automated planning and execution tools for the Army, and gives commanders the ability to build and share an automated common operational picture. The Army began development of the ABCS program in 1995 and the first platforms were fielded in 2000 (McGrath 2006, 220). The Army contracted Northrop Grumman Corporation to engineer a suite of automated systems capable of using the latest developments in satellite, tactical internet, and computer technology to track forces

(PM-FBCB2 Brigade Battle Command 2006). The overall concept was to modernize the process of providing real time or near-real time updates of the position of friendly forces on the battlefield and give commanders a common operating picture. Prior to the development and propagation of ABCS, updating battlefield graphics was accomplished using grease pens on acetate, and manually plotting and moving plastic icons on giant map boards (McGrath 2006, 200).

In 1994, the DOD established the Advanced Warfighter Experiments program to find ways to increase combat power using information technology networks (PEO-CBT n.d.). In 1995, the Army began development and fielding of ABCS as part of the Army Transformation Campaign, fielding the systems to the Fourth Infantry Division (Mechanized) for testing and evaluation. The Army Transformation Campaign originally involved initial fielding to all Army III Corps and Stryker Brigade Combat Teams starting in 2002. However, Army Chief of Staff General Peter Schoomaker accelerated the ABCS timeline due to the Global War on Terrorism. By 2005, the Army had fielded ABCS to all units deploying to overseas contingency operations (PEO-CBT n.d.).

The first generation of ABCS systems included a variety of networked systems for sharing information and intelligence products (Barton 2005). Over the past decade, advances in technology improved the performance of these networked systems. The increased SA and SU allows commanders to update and share a common operating picture instantaneously (PM-FBCB2 Brigade Battle Command 2010). Rather than going through the painstaking and time-consuming task of verifying the accuracy of unit locations on hundreds of map boards in all command posts over a radio network or

tactical phone, the overlays can simply be saved to a central server and accessed from anywhere in the network.

FBCB2 is a graphics-oriented battlefield tracking system that feeds ABCS and is the ground-force equivalent of Link 16. Most of the systems, referred to as FBCB2-Blue Force Tracker, use L-Band space-based satellite constellations, while about 30 percent, FBCB2, use the ground-based Enhanced Position Location Reporting System tactical internet to transmit information through a tactical internet using the Single Channel Ground Airborne Radio System very high frequency radio network (Barton 2005). A third variant, Blue Force Tracker-Aviation, is a satellite-based system installed in fixed-wing and rotary-wing aircraft. FBCB2 provides comprehensive SA through a common operating picture depicting the updated positions of friendly forces. The systems were fielded with installation kits for ground vehicles and rotary wing aircraft, as well as dismounted configurations for tactical operation centers and command posts. FBCB2 is credited as one of the main contributors to the successful invasion phase of Operation Iraqi Freedom's land campaign. There are currently more than 85,000 FBCB2 systems worldwide with updated software and hardware currently in development (Defense Update 2009a).

The new software, called Joint Capabilities Release, includes commercial mapping tools, better encryption, and new transceivers. The new transceivers will enable faster refresh rates and the ability to receive and stream live video from tactical databases or UAS's. Moreover, starting in 2004, research and development began for integrating the Land Warrior systems into ABCS (Jones et al. 2004). Once the two systems are merged, FBCB2 will be able to display a Soldier's location on a geo-referenced digital

map, much the same way ground vehicles and rotary-wing aircraft are currently tracked (Simental 2010, 10). FBCB2 is also being revamped to include several sister Service C2 programs and upon completion will be renamed the Joint Battle Command–Platform (McNew 2008).

As illustrated above, ABCS and TBMCS took significantly different paths to become the systems that exist today. The author found no evidence of the exact reasons for the separate ABCS and TBMCS stovepipes, but instead discovered that the Army, as along with the Navy and Marine Corps were engaged in the TBMCS development process. The Army Evaluation and Test Command represented the Army's interest as part of a Combined Test Force created by the Joint Chiefs of Staff to monitor and provide Service-specific requirements (Collens and Krause 2007, 16). The author concluded that the Army was already developing ABCS with the intent that it at some point would integrate with TBMCS. The TBMCS program delays, setbacks, and scaling back of capability to air battle planning only, caused the Army to move forward with a stovepipe ABCS program. The Army appears to have applied some of the lessons learned by TBMCS systems engineers. Program managers took a more cautious approach to program development and designated an entire Army division as a test bed and set an extended fielding timeline. At any rate, shortly after the Army and Air Force started fielding their respective systems, the U. S. was fully engaged in two separate overseas contingency operations. It took several more years, and the stabilization of the Army Force Generation cycle to develop an adequate fielding and development program that included training on updated interoperability features (Mackey 2009).

In terms of interoperability, both ABCS and TBMCS are compatible despite beliefs by Army and Air Force leadership to the contrary (Hinson and Summit 2009, 59). The icons depicting the position of ground forces can be displayed on the screens of systems used for tracking aircraft, such as the aforementioned Link 16. Using the SOA inherent in the structural design of both programs, feeds from any system within the ABCS or TBMCS software suites are visible on the other (Hinson and Summit 2009, 61). As illustrated in field reports filed by evaluators from organizations such as the Battle Command Training Program and Army Joint Support Team, the real issues lie in training shortfalls that have left commanders, staff officers, and operators unfamiliar with the features, capabilities, and applicability of the systems.

For example, according to several trip reports filed by Tiger Team personnel from the Army Joint Support Team located at Hurlburt Field, Florida, and Nellis Air Force Base, Nevada, ABCS and TBMCS are fully interoperable (Garcia 2008). The operators lacked the necessary training on how to subscribe to the appropriate server to receive the desired feeds. This is accomplished in much the same way operators are able to access live streaming video from UAS platforms and have the images piped in and displayed on large plasma screens in a tactical operations center or laptop screen in the commander's office. An example of this is the Combat Identification (CID) server, which enables blue force tracking in the cockpit and allows pilots to access FBCB2 and other ABCS feeds through the TBMCS system and Link 16, installed in the aircraft. The CID server bridges the two systems and provides the interoperability between data sources. Friendly locations are then piped into Link 16-enabled aircraft and are shown on the either the monitor or the pilot's Heads-Up Display, depending on the type of aircraft.

In answer to the first secondary question of this thesis, although specific Army and Air Force requirements differed in terms of air and ground operations the acquisition of these systems was based on similar demands. The Army required a two-dimensional system for depicting and sharing a common operational picture of units on the battlefield, determining the locations of friendly and enemy units, and the automated tracking of friendly forces movement in real-time. The Air Force needed a system capable of the more complex computations such as plotting three-dimensional air corridors and restricted operations zones, tracking and sharing the locations of aircraft moving through time and space at supersonic speeds, and calculating airspace deconfliction for hundreds of different aircraft. However, as previously stated, recent software upgrades including Publish and Subscribe Services, SOA, and CID Server, now bridge the gap between the two systems.

Based on the information gathered and studied regarding the original concepts for the two systems, the author found both programs to be fundamentally and conceptually the same. Other than the mission-specific software programming, DOD created both programs for the same basic purpose and under the same operational concepts. As illustrated in figure 2, DOD developed the original TBMCS and ABCS programs specific to each Service's functional mission with only a few exceptions. As depicted in the chart, at the time of initial fielding of ABCS and TBMCS, only the last three systems for each program were a duplication of effort (Krause 2005).

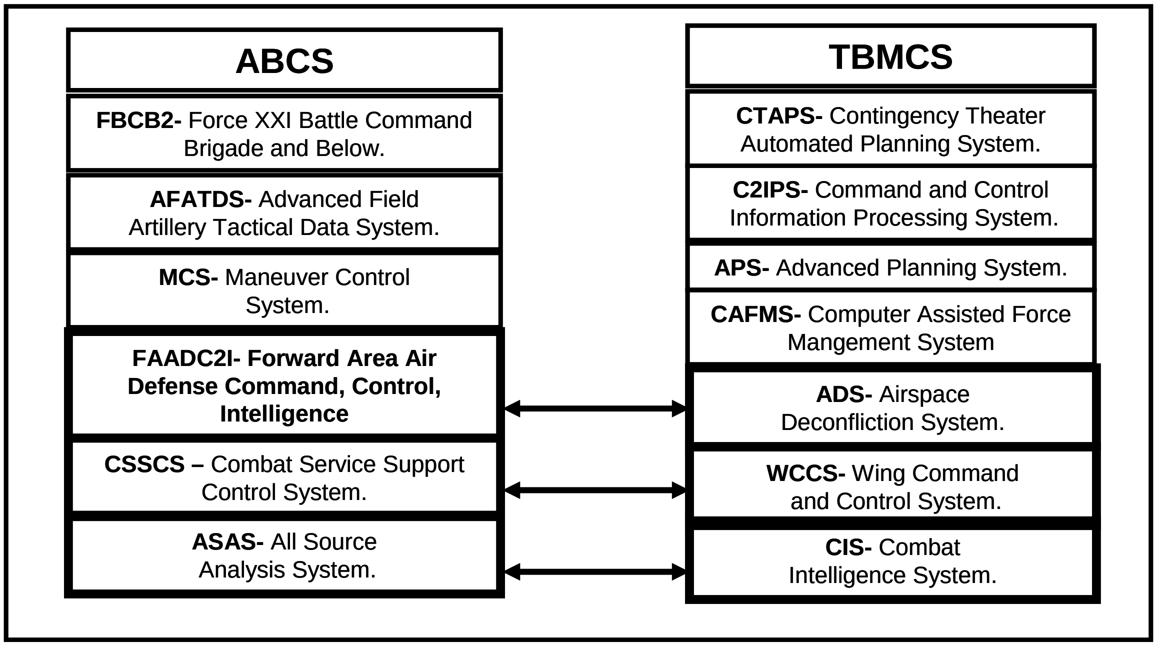

Figure 2. Comparison of Systems in Initial ABCS and TBMCS Programs
Source: Created by author based on "Army Battle Command System (ABCS) 6.4 User Tool Box (UTB)" CD-ROM, Version 1-1 (Fort Leavenworth, KS: Combined Arms Center-Training, 2006); Bob Krause, *Theater Battle Management Core System–Systems Engineering Case Study* (Wright-Patterson AFB, OH: Air Force Institute of Technology, 2005).

Essentially, the goal of each program was to leverage information technology for battle command, enhancing SA and understanding through information superiority. Both ABCS and TBMCS support the basic elements of battle command by answering these key questions: Where am I? Where are other friendly elements? Where are the enemy elements? What is the status and activity of each element (Biever and Wass de Czege 1998, 16)? Still, the Army and Air Force could have collaborated to develop and procure a common suite of systems under one program. An analysis of relevant literature led to and subsequently answered the next secondary question regarding the existence of so many different systems. The reasons neither Service effectively collaborated required

research beyond the intangible concepts of interservice rivalry and organizational culture, and into the complex arena of defense acquisition.

Acquisition is Joint Business

The vast array of graphics-oriented battlefield tracking systems is a product of an acquisition and procurement process for the DOD that both government and military leaders have been unable to successfully control. Over the last sixty years, the DOD has developed thousands of information systems (Vonglis and Wynne 2008). During the same period, there have been numerous attempts at acquisition reform with little actual reform occurring. While the DOD has struggled to reform the business practices regarding procurement of technology, technology itself has become more advanced. It has also become more readily available and affordable to our enemies. The strategic implications of being able to acquire and integrate information technology quickly and more affordably than our adversaries are increasingly important. However, it is imperative that current operational needs are reconciled with perceived future threats.

In a 2006 *Military Review* article, “Clouds and Arrows: Visualizing the Dynamics of Transformation,” Dr. Scott Stephenson, an Assistant Professor of Military History at the Command and General Staff College, Fort Leavenworth, Kansas, explains the concept of “thoughtware” as a critical link between technology and available resources in what is referred to as the trinity of transformation (Stephenson 2006). Leaders, decision makers, programmers, and information technology developers must apply thoughtware to answer the “what for” question regarding new technology. Central to the trinity of transformation model is the threat (figure 3). Current and future threats are the very reason for military innovation and transformation.

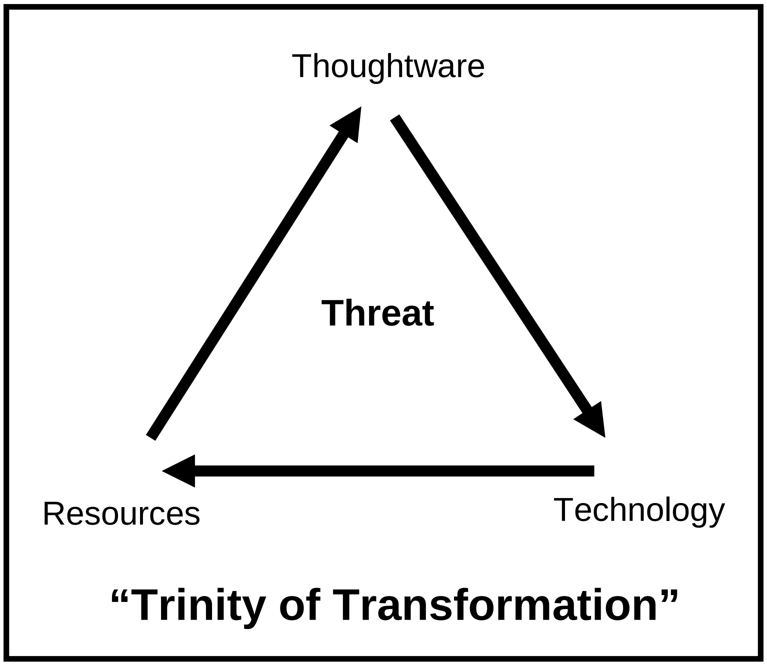

Figure 3. Trinity of Transformation
Source: Scott Stephenson, “Clouds and Arrows: Visualizing the Dynamics of Transformation,” *Military Review* (March/April 2006), http://findarticles.com/p/articles/mi_mlpb2/is_2_86/ai_n26853272 (accessed 28 April 2010).

However, thoughtware and threat are still subject to the biases of interservice rivalry and organizational culture, both of which are discussed later in this chapter. The current DOD acquisition process along with congressional mandates, the Secretary of Defense and the Chairman of the Joint Chiefs of Staff involvement, and new rules and regulations regarding the acquisition process are increasingly forcing the Services to apply “thoughtware” to the communications procurement plans. The aim of all of these measures is to find the important balance between immediate requirements and future threats.

The DOD acquired and developed the original ABCS and TBMCS programs under the Planning, Programming, and Budgeting System (PPBS). Before looking at

PPBE, it is important to explore and understand the characteristics and issues of PPBS, as it was the system used to acquire the ABCS and TBMCS programs. Then Defense Secretary Robert McNamara established PPBS in 1962 (Department of the Army, CGSC 2009, F104AA-1). The intent was to bring defense spending under control by eliminating the single-Service budgets submitted to Congress annually. Under PPBS, the Services were required to project requirements and submit a five-year budget for endorsement by the Secretary of Defense the sole approval authority. Unfortunately, PPBS was fundamentally flawed and especially ineffective for procuring technology.

First, the generating forces of both the Army and Air Force went forward with research and system development with little input from operational units. Second, as the single approval authority for changes, the Office of the Secretary of Defense soon became bogged down in requests for changes. This especially applied to the procurement of information systems due to the constantly changing nature of technology. As old technology became obsolete and was replaced by new technology, the Services would submit a change request for the new technology. To accommodate these and many other changes, the DOD added another layer of bureaucracy known as the Program Analysis and Evaluation office to screen and evaluate change requests. This led to a third issue with PPBS whereby the focus became more on affordability rather than operational demand or technical merit. Rather than submitting a budget proposal based on actual requirements, the Services submitted budget proposals containing items that were likely to be approved. Absent from the process was any type of joint oversight. In fact, although Goldwater-Nichols became law in 1986, the incorporation of Joint Planning Guidance and the Joint Capabilities Integration a Development System for providing joint oversight

was part of the transition from PPBS to PPBE that did not occur until 2003 (Department of the Army, CGSC 2009, F104AA-3). It was not until 2006 that the Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 3010-02b established the Joint Operations Concept mandating joint consideration when developing solutions to future military programs (Pace 2006). It was under the unilateral, undisciplined, and highly bureaucratic PPBS that the DOD procured TBMCS and ABCS.

The current PPBE process is the latest result of numerous changes and modifications to the DOD's methods of acquiring systems and equipment. The last major overhaul occurred in 2003 when the previous PPBS was changed to PPBE (Department of Defense 2009a, F103AB-1). The "execution" portion of the program was added to bring the first three phases of the process more in line with the realities in the field and the needs of combatant commanders. The intent was to connect Defense Department generating forces with the operational force and distribute resources more equitably.

Adding an execution phase also added the constraint of time-consuming Cost and Performance Measures Reviews (Department of Defense 2009a, F103AB-17). These corporate-style reviews involve routine meetings and are a paperwork-intensive, antiquated means of reviewing established strategic priorities. Also compounding the issue is the two-year timeline for the PPBE process. By the time a new capability program is ready to be executed, the information technology associated with that project is either obsolete or outdated. While the generating force is bogged down in bureaucracy, the operating force has found a way to circumvent the PPBE process. These types of strategies will benefit the Warfighter in the short term, but actually work contrary to achieving joint integration or interoperability.

Changing PPBS to PPBE by adding another phase did little to make the intended connection, especially in the development and acquisition of information technology. With the military fighting two wars simultaneously, the services were encumbered by a combination of the complex bureaucracy in place, the two-year timeline that the process takes, and a lack of oversight regarding the transformation initiative. Defense Department leadership took measures to reform the acquisition process. However, what was meant to be a more streamlined process at the DOD level based on current threat, instead opened up opportunities for operational units to exploit loopholes and circumvent the planning, programming, and budgeting aspects of the process.

Many program managers use so-called “internal funding” or “supplemental funding” to get around the PPBE process (Roosevelt 2006, 2). This allows them to forgo the submission of requests for inclusion in the Program Objective Memorandum and Budget Estimate Submission. Meanwhile, operational units use the Operational Needs Statement (ONS) to avoid the hassle of requesting new technology using normal logistics channels. The ONS process was originally a method for commanders to request war reserves during combat operations (Department of Defense 2008). The new ONS system allows commanders to take advantage of the rapid acquisition system, commonly referred to as rapid fielding initiative or rapid equipment fielding. During peacetime, a unit commander would request and wait for Modified Table of Organization and Equipment authorized equipment to make its way to the unit, either via production by the manufacturer or lateral transfer. It was reformed in response to nine years of continuous overseas contingency operations in support of Operations Iraqi Freedom and Enduring

Freedom to allow the quick procurement of commercial-off-the-shelf solutions to equipment or capability shortfalls.

Using ONS, commanders would opt to wait until the unit is in the “Train-Ready” pool of the Army Force Generation cycle just prior to a deployment. Either they were able to make a series of large purchases using contingency operations money, or ONS are submitted requesting larger purchases that would not have been authorized otherwise (Department of the Army, CGSC 2009, F104AC-4). Many of these special purchases and ONS result in non-program of record information technology being fielded to units. Meanwhile, program-of-record systems such as ABCS and TBMCS that already perform the required functions go unused. Soldiers and Airmen remain untrained and unfamiliar with how to employ the systems that were procured and developed by the DOD. Commanders continue to acquire new information technology, not knowing the capabilities of the systems already on hand. Furthermore, there is no standardization from unit to unit either in the type of systems or equipment. Instead of mitigating the acquisition process, the DOD actually created the current surplus accumulation of information systems. In the 26 July 2010 edition of *Army Times*, Lieutenant General Jeffrey Sorenson, the Army CIO-G6, remarked that in the past ten years, the Army “nearly doubled the types of radios it owns, from 11 in 2000 to 20 today” (Brannen 2010b). In that same timeframe, the Army inventory of radio systems has almost tripled, from 365,000 to 919,052. There are now almost as many radios as there are Soldiers.

However, the main reason the PPBE process has been ineffective is the continued lack of collaboration between the two Services. In fact, competing Program Objective Memorandum and Budget Estimate Solution submitted by each branch has led to

continuous inter-Service rivalry over procurement and a failure to assess whether or not there is a real need for the systems. Despite the emphasis on shared procurement set forth in the *Goldwater-Nichols Department of Defense Reorganization Act of 1986*, the Army and Air Force have gone their separate ways in pursuing new technology (U.S. Congress 1986). In fact, one of the duties of the Chairman, of the Joint Chiefs of Staff is to report any "unnecessary duplication of effort among the armed forces" and "changes in technology that can be applied effectively to warfare." Although the Armed Forces have pursued the latter quite diligently, the first part has been largely unsuccessful.

In addition to Goldwater-Nichols, there is a fair amount of regulatory guidance mandating joint interoperability as a part of the procurement process. *The National Defense Authorization Acts* passed by Congress for FY 2007, 2008, 2009, and 2010 all mandated the establishment and sustainment of an Office of Business Transactions to provide oversight transformation initiatives. Each bill specifically mentions information technology acquisition as an area of concern.

In DOD Directive 5000.01, *The Defense Acquisition System*, the Secretary of Defense fully supports the pursuit of information superiority and directs that all advanced technology with military applications be integrated in the shortest time possible (Department of Defense 2003b). DOD Directive 4630.5, *Interoperability and Supportability of Information Technology and National Security Systems*, directs that all information technology acquired must interoperate with existing and planned joint systems and equipment (Department of Defense 2004a). The directive also calls for the periodic assessment of joint interoperability and certification testing to ensure that all information technology is compatible across the Services.

Supplementing these directives are several CJCSI concerning the procurement and development of information technology. CJCSI 3170.01G, 6212.01C, and 6120.01C set forth the requirements for the use of Joint Capabilities Integration and Development System to ensure joint interoperability. The Chairman of the Joint Chiefs of Staff also sets best manufacturing practices by providing detailed instructions for the implementation of information technology interoperability and supportability certifications. Both the Army and Air Force Chiefs of Staff have stated in their respective vision (Casey 2010) and posture statements (Donley 2010) for Fiscal Years 2010 and 2011, the need for more focused logistics. Recognizing that the acquisition process needs to be improved, the Service chiefs are calling for the establishment of more integrated management systems for business operations. According to a trip report filed by the Theater Air Control System Integration Team for Air Force South, CJCSI 6271.01B, *Joint Standard Air Operations Software Configuration Management* was replaced by CJCSI 3265.01, *Command and Control Governance and Management* (Garcia 2008). CJCSI 6271.01B has been the primary letter of instruction outlining the joint process for the configuration management of programs such as ABCS and TBMCS.

CJCSI 3265.01 directs that all C4ISR systems will now come under the scope of the Joint Chiefs of Staff J3. Of significance is the Air Force's reinstatement of the Joint Air Operations Interoperability Working Group, discontinued after the 11 September 2001, attacks. The Air Force A3 and the Joint Forces Command J8 head the Joint Air Operations Interoperability Working Group. The working group ensures joint interoperability of C4I systems and processes and provides a key forum for raising and resolving joint interoperability issues and concerns. Bringing such processes back

emphasizes the importance of ensuring that C4ISR systems fielded are in tune with what the operational force needs.

Another approach the DOD is taking to systems design is to create greater process transparency through performance-based logistics. Performance-based logistics is a method of integrating logistics support into the overall design of a system (World Trade WT100 2008). It results in long-term support arrangements with clear lines of authority and responsibility. Due to technological advances, closer partnerships with industry throughout the lifecycle of a program are essential. The manufacturer is responsible for providing lifecycle engineers for the entire duration of the system's existence from fielding to disposal. These lifecycle engineers replace on-call field service representatives and are part of the overall logistics package (Thuermer 2009).

According to Jerry Cothran, Program Director for performance-based logistics at the Defense Acquisition University in Fort Belvoir, Virginia, performance-based logistics is not outsourcing (Cothran n.d.). Instead, DOD pays the supplier for a guaranteed level of performance and system capability. Logisticians are more involved in the system design process. As a result, DOD infuses support considerations earlier on in the process (Gardener 2008). This creates a more affordable method of acquisition with cost-savings over time. The DOD and the contractor both realize the savings via reduced inventory costs and the elimination of parts purchases and expensive technical service calls. Performance-based logistics saves the DOD money and increases quality by transferring most of the risk and maintenance costs to the supplier. DOD Policy, specifically DOD Directive 5000.01, *Defense Acquisition System*, identifies performance-based logistics as the preferred method for procurement support (Department of Defense 2003b).

Despite increased awareness, new certification requirements, and mandates for joint interoperability at the highest levels of the Defense Department going back to the first Joint Army and Navy Board in 1903, collaboration between the Services remains an issue (Kanewske 2002). In addition to the Army fielding ABCS and the Air Force TBMCS, the author found cases of stovepipe acquisition and duplication of effort in other areas of information technology used for C4ISR systems. A recent article published in the 12 April 2010, editions of both the *Army Times* and *Air Force Times* titled "GAO: Army, Air Force Should Have Collaborated on UAVs," identified missed deadlines, performance shortfalls, and budget overruns resulting from the development of the Army Predator program and a separate Air Force Sky Warrior program (Spoth 2010, 4). The U.S. GAO assessed that had the two Services collaborated on their UAS programs, taxpayers would have saved over $3 billion.

There are also examples of the benefits of joint collaboration in the development, and fielding of new technology. A 2006 *Defense Daily* article regarding the development of the Raven small UAS system provides an excellent example. Although the services did not collaborate to develop a singular UAS program, development of a portable system that allows Soldiers and Airmen to remotely downlink live surveillance images and geospatial data from tactical UAS has become a joint effort (Roosevelt 2006, 2). Cited in the article, Brigadier General Stephen Mundt, director of Army aviation in the office of the Deputy Chief of Staff, G-3/5/7, is a firm believer that the acquisition process is, "Joint business."

Brigadier General Mundt further explains how the Army's One System Remote Video Terminal (OSVRT) is essentially an Air Force Remote Operated Video Enhanced

Receiver III handheld computer terminal with OSVRT software, in addition to an ultra-high frequency modem and antennae required for use by ground forces. Although the Army and Air Force OSVRT and Remote Operated Video Enhanced Receiver III programs started out separately, the program managers eventually opted to work together and share technology. This allowed both projects to move forward more rapidly. The result was a jointly interoperable system providing commanders with a valuable C4ISR capability.

The OSVRT success story is an exception to the norm. Furthermore, despite presenting the article as an example of transparency and joint interoperability, the fact remains that initial development of both Army OSVRT and Air Force Remote Operated Video Enhanced Receiver III programs occurred in the usual stovepipe fashion. It is also another example of how program managers are not using the PPBE process. The product director, Lieutenant Colonel Jennifer Jensen, states in the article that the OSVRT program started about a year ago from "internal funds," and was not a program of record.

Technology is constantly changing and improving. Therefore, technological development and acquisition occurs at more of a steady crawl than distinct jumps (Murray and Millet 2008, 20). However, due to the current acquisition process, decision makers react incrementally instead of keeping pace with the reality of the process. The entire process calls for reformed acquisition, requirements procedures, and information that is more accurate from commanders in the field (McHugh and Casey 2010). The aim is to integrate as much of the latest technology as possible to deliver applications to the Warfighter. Deputy Defense secretary William J. Lynn III, advocating platform standardization, recently stated in an article for the *Association of the United States Army*

magazine “How we integrate information technology into our operations and structure its acquisition is among the most important determinant of our military power” (Association of the United States Army 2010a, 2). A key constraint to reaching this goal is money. In the memorandum *Calendar Year 2010 Objectives* co-authored by Army Secretary John M. McHugh and Army Chief of Staff General George W. Casey, the proposed need to “refine the Army for the 21st Century” is further qualified with the need for an “affordable modernization strategy.”

President Barack Obama made numerous statements regarding military spending shortly after taking office. Recognizing that there was far too much waste in the defense budget, he quickly moved to terminate costly projects such as the F-35 fighter jet engine and the VH-71 Presidential Helicopter (Reuters 2009). In the article, the President predicted that more budget cuts and project terminations were forthcoming. In a February 2010 *Time* Magazine article, Defense Secretary Robert M. Gates stated that the “Pentagon budget will be shifting from theoretical, conventional wars to the unconventional ones the military is fighting now” (Rubin 2010, 29). A prime example of this shift was the recent cancellation of the Future Combat Systems program, and the development, production, and delivery of the Mine Resistant Ambush Protected vehicles aimed at defeating the improvised explosive device threat prevalent in the Iraq and Afghanistan theaters of operation. Closer to the topic of this thesis was the cancellation of the Net Enabled Command Capability program.

The Net Enabled Command Capability was under development, touted as the DOD’s principal C2 capability accessible in a net-centric environment. The DOD had intended the system to provide the Commander with the data and information needed to

make timely, effective, and informed decisions (Gallagher 2009). Net Enabled Command Capability was a joint program, led by the Defense Information Systems Agency. The proposed program was to become the primary system used by all Services to improve interoperability, collaborative planning and rapid decision-making across all Joint warfighting functions at the Secretary of Defense, Chairman of the Joint Chiefs, Combatant Command, Joint Task Force, and Component levels. However, due to numerous delays in the development, integration, and testing, Secretary of Defense Robert Gates cancelled the program.

From the preceding paragraphs, one can determine that the DOD recognized the need for maintaining a technological edge, gaining information superiority, and the fulfilling U.S. Code Title 10 requirements. Nonetheless, it is widely recognized that there is a considerable amount of wasted time, taxpayer dollars, and effort in the current military acquisition process.

Interservice Rivalry vs. Interoperability

From unique uniforms to the variety of military customs, courtesies, and traditions, interservice rivalry has always existed between the Services and is part of military organizational culture. This rivalry is deeply rooted in the collective history of each organization (Roefels 2009). For example, the author examined Air Force efforts to bring Army and Marine air power assets under the control of the tactical air control system during the Vietnam War (Horwood 2006, 139). The large amount of each Service's defense budget allocation tied to their respective aviation fleets fostered resistance to putting all air power under one C2 center. Despite obvious tactical and operational advantages apparent from such events as the successful defense of Khe Sanh

in 1968, numerous combined airborne resupply drops, CAS and CCA missions, no commander was willing to relinquish control of its air power. In fact, such disunity of command went so far as to assume that each Service could win the war unilaterally (Record and Terrill 2004, 20). Such extreme Service parochialism further fed the fires of interservice rivalry.

There are two explanations for the enduring existence of interservice rivalry. The primary reason is that up until 1986, each Service essentially operated as an autonomous government department, devoid of effective civilian control, and with interdepartmental rivalries that had been cultivated for almost two-hundred years. At the highest levels of the DOD, this rivalry manifests itself in competing Program Objective Memorandum and Budget Estimate Solution seeking approval for multi-billion dollar projects. Based on the research, the resistance to collaborate on information technology projects is a product of U.S. military culture and primarily driven by these competing Service budgets. Based on statements by senior government officials, to include the commander-in-chief, budget constraints are going to become even more of a concern in the coming years. In fact, there are close ties between budget and many of the major examples of interservice rivalry throughout the military's history.

More recently, interservice rivalry became deeply rooted in military culture during the Cold War. The current heritage of interoperability or lack thereof, is a product of the geographic sectors assigned during the Cold War (Ooms 2004, 17). For example, the European Command Commander's focus and required capabilities during the Cold War differed from those of, say, the Southern Command Commander. These sectors were eventually developed into what is known today as the Unified Command Plan

(Department of Defense 2010d). But prior to the end of the Cold War, each geographic sector also enjoyed a certain degree of autonomy in terms of acquisition. The differences in proximity to and availability of suppliers also affected how and from whom the different systems were procured. The geographic isolation resulted in the isolated procurement of different proprietary equipment. This proprietary equipment was industry dependent, such as the previously mentioned Mobile Subscriber Equipment (Quinn 1996, 52). As was the case that brought about the establishment of the Institute of Electronics and Electrical Engineers, communications industries will only develop common standards under pressure from the user community (IEEE 2010).

This practice of stovepipe acquisition was therefore the acceptable method of acquisition and it continued to be throughout the 1990s. Prior to Goldwater-Nichols, both Services were very disjointed in the way they operated. Even after congress passed the act in 1986, the Services still found themselves competing for government funds. The Cold War ended three years later and, following Operation Desert Storm, an intensive drawdown of the Armed Forces occurred that lasted throughout the 1990s. However, successful air and ground campaigns by both the Army and Air Force gave them the political clout needed to obtain budget allocations to pursue separate C4ISR programs. The Air Force continued promoting its need for technology, the importance of strategic bombing, and relevance of air power. The Army kept on acquiring more capability while promoting the importance of ground forces and the ability to close with and destroy the enemy. The Army and Air Force remained politically divided without enough emphasis on joint interdependence. Budgets and Program Objective Memorandums became even more competitive.

To answer the second secondary question, the reason for the different graphics-oriented battlefield tracking systems employed by the Army and Air Force is due to a combination of acquisition process shortfalls and organizational culture. Both Services had identified a demand for graphics-oriented battlefield tracking systems based on specific Service needs. The Army needed a system for tracking ground forces while the Air Force required a system capable of the more complex tracking of aircraft. Based on these somewhat divergent requirements, both Services went about the acquisition process based on the acceptable methods and best practices of that time, albeit separately. Such was the climate in 1995 when the Secretary of Defense charged the Army and Air Force with leveraging the latest technology to develop a C4ISR system capable of achieving information superiority. More than a decade later, the Services are still finding it difficult to make the paradigm shift. The Army and Air Force have been unable to move completely from separate and unilateral acquisition processes for procuring information technology to one of collaboration and cooperation between branches.

Cultural vs. Technological Compatibility

The DOD has acquired many systems over the years and touted them as being "joint" systems. Only Air Force ground controllers use equipment such as the Joint Base Station Variant II Radio System to maintain contact with aircrews (Agency Group 09 2009). Likewise, only the Army uses the Joint Network Transport Capable Spiral fleet for wide-area networking. Usually only one Service employs these systems in a limited role as a joint communications asset (Highbeam Research 1995, 1). Simply placing the word "Joint" in front of a system's name may improve a project's chances for funding approval, but it does little in terms of true joint interoperability. Technology and funding

is not the issue. As explained above, the technology and the expertise to integrate that technology is readily available. The true challenges are organizational in nature. Developing a truly joint system for both the Army and Air Force requires more leadership emphasis on eliminating the current culture of interservice rivalry while identifying and correcting training shortfalls. The next secondary question, whether or not having different systems negatively affect Army and Air Force operations, required the author to research several cases involving fratricide, collateral damage, or degraded support.

Case Study Analyses

U.S. and coalition forces must adapt tactical approaches and techniques in a way that prioritizes avoidance of civilian casualties, fratricide, and friendly fire incidents (Wendel 2010). The potential for instances of friendly fire, fratricide, collateral damage, and delayed CAS and MEDEVAC support during joint Army and Air Force operations is increased due to interoperability issues between systems. According to the results of several Multi-National Forces-Iraq and Central Command 15-6 investigations, fatigue and carelessness coupled with the increased lethality of weapons systems contributed to incidents of fratricide and collateral damage in Iraq. However, a lack of training on ABCS systems primarily caused a majority of these incidents (McNew 2008). This includes the unfortunate shoot down of a Royal Air Force (RAF) Tornado Fighter Jet by a U.S. Patriot Missile at the beginning of Operation Iraqi Freedom in March 2003 (Directorate of Air Staff 2003). The lack of training resulted in either the shooter or the victim lacking adequate SA prior to the incident.

The following paragraphs summarize the author's analysis of three recent cases of delayed CAS or MEDEVAC support, fratricide, and collateral damage, where different systems potentially affected Army or Air Force operations negatively. Each incident involves personnel and equipment of both Services, shortcomings in joint interoperability to include human error, equipment failure, or other circumstances. The aim is to determine negative impacts by examining the types of incidents resulting from the Clauswitzian "friction" and "fog of war" (Clausewitz 1984) that the TBMCS and ABCS programs were designed to prevent.

Complex Attack on Combat Outpost Keating

At 5:58 a.m. on 3 October 2009, Bravo Troop, 3-61 Cavalry Squadron, 4th Brigade Combat Team, 4th Infantry Division, Fort Carson, Colorado, came under attack by between 250 to 300 Anti-Afghanistan Forces (Roggio 2010). The unit was occupying Combat Outpost Keating in the Kamdesh District of Nuristan Province, Afghanistan with the mission of interdicting a known main smuggling route for drugs, minerals, and other commodities from Afghanistan to Pakistan (Department of the Army 2010a). The battle lasted more than thirteen hours and involved dismounted maneuver, MEDEVAC, Air Assault, CAS, CCA, and indirect fire (Lessig and Puetz 2009). Although only the executive summary from the official 15-6 investigation report completed by Lieutenant Colonel Guy Swan is unclassified (Tan 2010), the information it contains along with reports and first-hand video accounts from five other sources were adequate for a thorough analysis of the battle in the context of this thesis.

The issue relevant to this research paper was the delayed arrival of CAS during the battle. The first F-15 Eagle fighter jet arrived on station 1 hour and 20 minutes into

the battle, followed shortly thereafter by UAS and CCA assets (Department of the Army 2010a). After a thorough review of nine separate accounts of the battle, the author concluded that low visibility due to weather and fog obscuring the battlespace and not integration issues between ABCS and TBMCS caused the delay. Once the weather lifted, any subsequent degradation of CAS, UAS, or CCA support was due to the arduous terrain and heavy smoke rising from the buildings and vehicles on Combat Outpost Keating and obscuring the battlespace (Lessig and Puetz 2009). Despite reports of degraded communications due to a destroyed generator during the initial enemy mortar barrage (Lowry 2009), there is no report of interoperability issues between ABCS and TBMCS systems used to coordinate MEDEVAC, UAS, CCA, indirect fire, and CAS. In fact, all evidence points to the contrary.

From the CAS perspective, F-15, F-16, A-10, B-1, and AC-130 aircraft supported the troops in contact and remained on station for a total combined twenty-one hours. In all, forty-four types of fixed-wing aircraft entered and operated within an extremely tight battle space where CCA and UAS were also operating. Twelve UAS platforms comprised of Predator, Reaper, U2, Globalhawk, and Redridge aircraft provided support. This was in addition to twenty-two separate rotary-wing aircraft, including UH-60s, HH-60s, AH-64Ds, and CH-47s, which provided MEDEVAC, CCA, and airlift support for the Quick Reaction Force (Department of the Army 2010a). A total of seventy-eight aircraft effectively provided continuous support to ground forces with three AH-64 Apache helicopters returning to base due to damage by enemy fire (Roggio 2010). In a series of video interviews with *Military Times*, 3-61 Cavalry Squadron leadership credit the

effective application of CAS and CCA with changing the tide of the battle and allowing Bravo Troop to launch a successful counter-attack (Lessig and Puetz 2009).

In an *Air Force News* article, First Lieutenant Cason Shrode, the Fire Support Officer at Combat Outpost Keating during the battle recounts, "we had so many different assets up in the air . . . they were stacked up on so many different levels" (Jung 2009). First Lieutenant Andrew Bundermann, a Bravo Troop Platoon Leader, stated that the aircraft "got there as fast as they could" and "dropped on targets we told them to drop on" (Lessig and Puetz 2009). The Soldiers were able to kill the Anti-Afghanistan Forces inside the perimeter and regain control of the base (Roggio 2010).

The tight concentration of Army and Air Force assets required close cooperation to deconflict the airspace. Lieutenant Colonel Robert Brown, the squadron commander, stated that the "ability to keep a steady flow of aircraft and ordnance on the enemy turned what could have been a terrible defeat into a hard fought victory" (Jung 2009). In this case, there was no negative impact caused by different Army and Air Force systems.

Royal Air Force Tornado Shoot Down

The fratricide incident examined involved the engagement and destruction of a British RAF Tornado Fighter Jet by a U.S. Army Patriot Surface-to-Air Missile at the beginning of Operation Iraqi Freedom. An official accident report published by the British Ministry of Defence and endorsed by United States Central Command formed the basis for the analysis. Unfortunately, this was not an isolated incident. Less than two weeks later a U.S. Navy F-18 Hornet was shot down, killing the pilot, while additional separate incidents involved near misses of another U.S. Navy F-18 and an U.S. Air Force F-16 Fighting Falcon (Almond 2004). The results of the U.S. investigations into all

friendly fire incidents involving the Patriot Surface-to-Air Missile were not available for this research paper.

The issue relevant to this research paper is the combination of TBMCS and ABCS systems used for tracking coalition aircraft and the failure of both to act effectively as a fratricide countermeasure. After careful analysis of the official accident report, it is determined that human error, lack of training, and non-availability of communications equipment caused the incident.

At 2:48 a.m. on 23 March 2003, local Iraqi time, the RAF Tornado Fighter Jet was returning to Ali Al Salem Air Base, Kuwait when a U.S. Army Patriot Surface-to-Air-Missile struck the aircraft (Directorate of Air Staff 2003, 3). The Patriot crew had incorrectly identified the Tornado as an Iraqi Anti-Radiation Missile. The Patriot missile killed both members of the crew instantly. At the time of the incident, the crew was monitoring for Iraqi Tactical Ballistic Missiles. Due to the flight path and speed at which the Tornado was flying, the symbol that appeared on radar indicated that an Anti-Radiation Missile was inbound to their location. The Patriot's interrogator radar queried the aircraft for Identify Friend Foe authentication and received no response. Having met all classification criteria, the Patriot crew launched the missile, and destroyed the Tornado.

Of the seven factors found to have contributed to the accident, four are pertinent to this study. First, the Patriot system identifies hostile missiles through their flight profile and other characteristics, including the lack of a response to a code interrogation. The baseline criteria programmed into the Patriot computer are very general and based on the many different Anti-Radiation Missiles available worldwide. The crew involved in

the incident did not program their systems for threat Anti-Radiation Missile classifications specific to the operating environment based on the known threat from Iraq. The generic criteria programmed into the Patriot computer contributed to the accident.

The board also concluded that the Patriot Missile Crew's doctrine and training contributed to the accident. The Army trains Patriot crews to react quickly, engage within one minute of target acquisition, and to trust the Patriot system. Given more time, the Patriot system may have reclassified the Tornado as its flight path changed. Additionally, most of the unit's Air Missile Defense Workstations were still en route from the continental U.S. so the crew's view of the common air picture was limited to radio relays from the battery command post. Despite this degradation in communications systems capability, the unit did not adjust the doctrinal one-minute time standard for engaging. Although the crew, fully trained to standard on Patriot system battle drills, the training doctrine focused on recognizing generic threats. The crew conducted no training on threats specific to the Iraqi theater of operations or on identifying false alarms.

The third applicable finding was that the autonomous operation of the Patriot Battery contributed to the incident. Without the Air Missile Defense Workstation network, the crew lacked the widest possible COP of the airspace around them to gain SA. The board concluded that had the crew access to a better operational picture, it is likely the Patriot team would have been identified the Tornado as a friendly aircraft. Finally, the investigation showed that the Patriot's code interrogator was working, but the Identify Friend or Foe equipment on the Tornado was not. Although the board considered pilot error, the investigation concluded that the Identify Friend or Foe system had most likely experienced a power supply failure unbeknownst to the crew. This fault rendered

the Tornado incapable of sending an Identify Friend or Foe response to the Patriot's interrogator radar.

In his book, "*Amicicide: The Problem of Friendly Fire in Modern War*," LTC Charles R. Shrader found that incidents of fratricide during World War I, World War II, the Korean War, and the Vietnam War accounted for only 2 percent of total casualties (Shrader 1982). Despite the U.S. technological superiority over the Iraqi military during Operation Desert Storm, the U.S. suffered thirty-five Killed in Action and seventy-two Wounded in Action due to friendly fire. Of those Killed in Action, ground-to-ground action caused twenty-four while eleven were a result of air-to-ground action. Additionally, of the ten U.S. tanks destroyed during the Gulf War, seven were destroyed by other U.S. tanks while twenty-three of the twenty-eight Bradley Fighting Vehicles lost were due to friendly fire (Doton 1996, 11).

In contrast to the wars studied by Shrader, the incidents of fratricide in Desert Storm accounted for 24 percent of combat fatalities. These statistics were the catalyst for the pursuit of better C2 technology and high demand for enhanced SA. But based on friendly fire statistics for Operations Enduring Freedom and Iraqi Freedom, where fratricide incidents thus far have accounted for 35 percent and 12 percent of casualties, respectively, one would argue that technology is not the answer (Sanchez 2004), nor is it necessarily the problem.

In a study by the U.S. Army Aero Medical Research Laboratory: Warfighter Performance and Health Division at Fort Belvoir, Virginia (Hewett 2010), out of the twenty fratricide incidents analyzed between 11 September 2001 and 31 March 2008, the most common causes were non-technical in nature. Instead, poor leadership caused the

majority of incidents due to a lack of information sharing or allowed unsafe acts to occur. The study found that 80 percent of the mishaps were due to human error on the part of either the victim or the shooter. Of the twelve incidents citing communications and information systems as contributing factors to the incident, the primary cause was a lack of training.

In the case of the RAF Tornado shoot down, interconnectivity issues between TBMCS and ABCS did not cause the incident. Had the systems been available and employed properly as technical countermeasures to fratricide, the incident could have been avoided. Instead, training shortfalls, system failure, and non-availability of equipment resulted in an unfortunate but preventable accident.

The Azizabad Airstrike

The final case examined of the type that ABCS and TBMCS were designed to prevent involves an incident of collateral damage from CAS resulting in civilian casualties in Afghanistan during Operation Enduring Freedom. On 22 August 2008, U.S. Special Forces and Afghan Commandos came under fire from Azizabad, a small village located in the Shindand District of Herat Province, Afghanistan (Human Rights Watch 2008). In response to the enemy contact, requested CAS dropped two 500-pound bombs on the insurgents, neutralizing the threat but also killing a number of civilians unfortunately in close proximity to where the bombs landed. The United Nations estimated the number of civilian casualties to be between seventy-eight and ninety-two and included women and children. The final reported civilian death toll by Combined Joint Task Force 101 was much lower at thirty-three (Straziuso 2008). There is very little information available on the technical aspects of this or any other incident of collateral

damage in Iraq or Afghanistan. The military will not release the results of the official investigations due to security classification and the majority of news reports focus on the civilian casualties and the strategic or political implications.

In the absence of reports or information to the contrary, one can assume that interconnectivity issues between TBMCS and ABCS did not cause the incident. Nor was the resulting collateral damage a result of tactical operation centers having too many C4ISR systems with which to contend. Special Operations Forces and their Afghan Commando counterparts came under fire from insurgents in Azizabad and responded with small-arms fire and CAS. The Air Force F-16 dropped its ordnance in close proximity to the village resulting in the unfortunate death of a still-disputed number of civilians (Human Rights Watch 2008). Essentially, the C4ISR systems employed worked properly. Ground forces requested CAS, which delivered high-explosive ordnance to destroy the enemy successfully.

Despite a lack of information on the Azizabad incident, the author reviewed a number of other collateral damage incidents and statistics for the resulting civilian casualties. Every incident involved civilian casualties. In a report released by the United Nations Human Right Watch (Human Rights Watch 2008), an estimated 116 Afghan civilians were killed by thirteen Operation Enduring Freedom and International Security Assistance Force airstrikes in 2006. In 2007, Afghan civilian deaths increased threefold to 321 resulting from twenty-two bombings. In the first seven months of 2008 leading up to the September release of the Human Rights Watch report, twelve airstrikes accidentally killed at least 119 Afghan civilians. These numbers also include the Azizabad incident. The increase in collateral damage is alarming. In addition to these

statistics, Human Rights Watch also had two recommendations for the employment of weapons systems (Human Rights Watch 2008): stop using airstrikes in densely populated areas without highly reliable intelligence and visually identifying the target; and refrain from using 105mm Howitzers or similar area-effect weapons against targets in densely populated areas.

It would appear that the former commander of coalition forces in Afghanistan took these recommendations to heart (Bay 2010). General Stanley McChrystal strongly emphasized protecting the civilian population in his overall campaign strategy. Doing so countered both the Taliban tactic of using human shields and the strategic setbacks inherent with civilian casualties from coalition bombs.

In addition to an overall strategy, counterinsurgency training, and better use of technology can aid in preventing collateral damage. Planned airstrikes often involve a thorough intelligence preparation of the operating environment, and normally result in less collateral damage. In contrast, targets of opportunity or rapid-response strikes such as CAS, CCA or indirect fire have a higher probability for collateral damage (Human Rights Watch 2008). To facilitate better intelligence, the coalition must increase its intelligence, surveillance, and reconnaissance capabilities in Afghanistan. The ground force commander can better determine the probability of civilian casualties with better information. Normally, CAS from fighter jets can arrive on station much faster than UAS assets. The pilots often drop ordnance on the target through cloud cover, smoke, or under other circumstances where visual identification of the target by the troops in contact, the forward air controller (airborne), and the fighter pilots is not possible.

One recommendation from the U.S. Army War College is to upgrade the video pods currently attached under the nose of fighter jets and bombers, enabling CAS with a live feed accessible by the ground force commander via OSVRT or Remote Operated Video Enhanced Receiver III (McFeely 2009, 27). This will allow for a synchronized targeting picture and a clearer vision of what is in the location where the ground forces want to drop bombs. Meanwhile, training intelligence personnel, joint terminal attack controllers, and aircrews on counterinsurgency will help them understand the implications of their actions beyond the tactical and operational level and make better decisions. The U.S. military must adapt its approach and techniques in a way that prioritizes avoidances of civilian casualties (Wendel 2010).

From the analysis of the three cases, the answer to the third secondary question is "no." The study of the preceding cases revealed no evidence system interoperability or having too many systems distributed between the Army and Air Force caused any of the incidents. Factors other than technology caused the delayed arrival of CAS and CCA at Combat Outpost Keating, the incident of fratricide involving the RAF Tornado, and the unfortunate incident of collateral damage in Azizabad. Instead, one or more other factors caused all three including terrain, weather, human error, mechanical failure, and training shortfalls. Researching training and other challenges to developing and achieving a truly joint system for both the Army and Air Force was necessary to answer the fourth secondary question.

Correcting Training Shortfalls

One of the Army's principles of training is to "Train as you will fight" (Department of the Army 2008b). This means training for proficiency in both combined

arms operations and unified action. The current operational environment requires unified action through joint interdependence between the Army and Air Force. For ground forces, the Army Battle Command Training Strategy mandates training for all Soldiers on digitized battle command systems. It also identifies and establishes proficiency with those systems as a core competency (Greystones Group 2009). The Battle Command Officers Integration Course, Command and Control Digital Master Gunner Course, and the Battle Command Integration Course are institutional training solutions geared towards providing leaders with the skills necessary to leverage information technology effectively (Mackey 2009). The meaning of combined arms operations has evolved past the traditional combination of artillery, armor, CCA and ground troops. It is taking on more joint connotations involving the full synchronization of ground and air forces during combat (Vessey 2010, 12). The integration of CAS at lower echelons in the conventional force is more common and the access to this support is becoming more and more decentralized. Better integration is needed between the Army and Air Force to synchronize the ground scheme of maneuver with the Air Tasking Order. Leaders at all levels need to understand how joint forces operate to be able to make better decisions. A key to this is to know the capabilities of the graphics-oriented battlefield tracking systems available, especially in terms of joint interoperability.

A 2008 trip report filed by a member of the Air Force and Marine Corps Tiger Team covering site assistance visits throughout the Central Command area of responsibility 8-20 January revealed that TBMCS was not being used in theater Combined Air Operations Centers as it was intended (AFMCTT CENTCOM 2008). Specifically, there was a perceived lack of functionality by both commanders and

operators due to a lack of training. For those operators who did have some knowledge of the systems, the perceived complexity of using TBMCS resulted in a preference for Microsoft Windows-based software such as Microsoft Excel and other non-programs of record software. Operators used TBMCS for production but not execution. The use of these basic software programs may be feasible for the current level of irregular war sorties in Operations Iraqi Freedom and Enduring Freedom. However, Microsoft Power Point and Excel would become grossly insufficient for the production and execution of Air Tasking Orders. The Combined Air Operations Center would have to use TBMCS and potentially face significant training challenges.

An April 2010 executive summary written by a TRADOC Capability Manager Battle Command representative from the Combined Arms Center at Fort Leavenworth, Kansas described a similar situation regarding ABCS. The report noted several ABCS training shortfalls during a recent trip to Afghanistan. In addition, many units had placed very little command emphasis on ABCS training and education based on the lack of knowledge and understanding regarding its capabilities. Operators were not knowledgeable on the full range of ABCS upgrades. Leaders were not aware of the detailed information available to them through the various ABCS functions. Consequently, these units were unable to utilize features such as the Publish and Subscribe Service, which enables the units to share information between ABCS systems such as Command Post of the Future, FBCB2, and Advanced Field Artillery Tactical Data System successfully.

As with any other weapon or system, commanders and senior leaders need to understand the full potential of TBMCS and ABCS capabilities. They must recognize

how features such as the Publish and Subscribe Service and CID servers facilitate the sharing of data between the two systems. Operators and network personnel require training to execute the necessary steps that set up the systems for this higher level of information sharing. Historically, Air-to-ground integration issues resulted from either lack of training or communications equipment that was either unreliable or not compatible. These were certainly the findings of a January 1995 Joint CAS Test and Evaluation Interim Report from the Center for Army Lessons Learned at Fort Leavenworth, Kansas (Campbell 1995).

Unreliable or incompatible communications equipment is no longer an issue. In the twelve years between the Gulf War and Operation Iraqi Freedom, the military has noticeably closed the capability gap in demand for communications infrastructure (Moseley 2003, 70). During Operation Iraqi Freedom in 2003, the amount of available C4 infrastructure had markedly increased compared to Operation Desert Storm in 1991. Fifteen years after the Joint CAS report, the technology is right and systems exist that are both reliable and compatible. However finding the time and resources to effectively train on interconnectivity methods, integration of data, and system capabilities is still the greatest challenge (Vonglis and Wynne 2008). A Center for Army Lessons Learned newsletter on Army and Air Force integration published in 2008 included the initial report from a joint team from both the Center for Army Lessons Learned and the Office for Air Force Lessons Learned (Mangus 2008, 35).

In 2006, the nine-member collection and analysis team focused on Army and Air Force Command and Control operations during Operation Iraqi Freedom and Operation Enduring Freedom. One of the key findings of the group was the need for more training

on the systems of record used in theater. Since on-the-job training takes more time than the normal fifteen-day relief-in-place timeline allows, the team recommended that training be conducted prior to deploying. Therefore, command emphasis and access to the systems is imperative to ensure training occurs.

Current Army and Air Force digital systems training programs are not adequate in relation to the sophistication of the systems and operational deployment rates (Findley and Luck 2008, 8). According to the Army Digital Training Strategy and Air Force's Air Education and Training Command's technical training programs, operators must go through up to eighty-four months of instruction and hands-on operation to become proficient. The training ranges from basic skills and familiarization during new equipment training, sustainment and development skills, and culminating with the operator capable of incorporating changes and upgrades.

It is highly unlikely that an operator new to a unit or working with a new system or version of a system for the first time will be proficient in that system prior to deploying to combat (McNew 2008). Personnel turnover, twelve to eighteen-month dwell times, and availability of equipment and facilities prevent it. Additionally, due to scheduling conflicts and resource constraints, many units resist or fail to send the right people to New Equipment Training. For example, New Equipment Training for FBCB2 version 6.5 was 32 to 40 hours (PM-FBCB2 Brigade Battle Command 2006). In addition, Servicemembers usually complete institutional training as part of reset following a deployment. This is also a high activity period for permanent change of station moves and block leave. New Equipment Training also has to compete with other professional development courses such as the Warrior Leader's Course and other Noncommissioned

Officer Education System programs. Furthermore, New Equipment Fielding usually occurs just prior to deployment, not immediately after it.

From an institutional standpoint, the highest levels of TRADOC are aware of the need for better and more focused training. In a recent interview, Lieutenant General Robert D. Caslen, Junior, Commander of the Combined Arms Center, relayed a first-hand understanding of the importance of networking (Bower 2010, A-1). As the Multinational Division North Commander in Iraq from 2008 to 2009, Lieutenant General Caslen was able to C2 over 23,000 Soldiers, Airmen, Sailors, Marines, and civilians using a vast array of C4ISR systems. He also stated that one of his main priorities as the Combined Arms Center Commander was training on exploiting those system capabilities.

In terms of facilities, all major installations are establishing Battle Command Training Centers. These digital training centers allow units to train on all C4ISR systems in an integrated, joint interoperable environment (Association of the United States Army 2009a).The ability to replicate complex scenarios at home station provides an affordable alternative to costly and resource intensive national training exercises. New approaches to training in high-intensity ground conflicts as well as replicating cultural environments and non-kinetic operations can be achieved with simulations (Schultz 2010, 71). The innovative programs offered by the Battle Command Training Center allow Army and Air Force units to take advantage of the latest research and technology while gaining the needed proficiency in C4ISR systems operation, integration, and interoperability.

Real joint interdependence and interoperability requires a revolution in military affairs conceptualized by a change in military culture (Knox and Murray 2001, 12). However, as with any revolution in military affairs, there is always resistance and

difficulty in implementing the needed changes. Organizational cultural change, especially of this magnitude, is a long-term effort, requiring leadership emphasis, and can take decades (Wendel 2010). The Army and Air Force are currently in the middle of such a shift. The recent changes in mission parameters, operational requirements, and budgetary constraints are driving these patterns of change, innovation, and adaptation (Knox and Murray 2001, 12).

Nine years of continuous combat operations and overseas deployments have contributed greatly to breaking the parochial mentality of military culture. Civilian and military leaders have increased awareness of the issues and benefits of joint interoperability. These issues and benefits have social and political implications as we enter the interwar period following the impending end of combat operations in support of Operations Iraqi Freedom and Enduring Freedom (Murray and Millet 2008, 13). Military and civilian leaders will be faced with challenges to military innovation and maintaining the tremendous strides towards total joint interoperability that have been made since 11 September 2001.

The answer to the fourth secondary question posed by this research paper is twofold. The challenges to developing and achieving a truly joint system for both the Army and Air Force stem from a combination of organizational culture and shortfalls in training. Both Services attempted to meet obligations under Title 10, U.S. Code, while contending with interservice rivalry, organizational culture, loopholes in the acquisition process, and budget limitations. These efforts resulted in a wide variety of C4ISR systems fielded. It will take a considerable amount of time and effort to bring those systems to an acceptable level of joint interoperability (Comanor et al. 2009, 75).

Shortfalls in training on these systems, either on-the-job or institutionally, prevents collaboration and keeps Servicemembers from gaining the knowledge and proficiency to make the systems work together.

The Long Road to Interoperability

After examining current doctrine, reviewing relevant incidents and issues emerging from Iraq, Afghanistan, and other joint operations involving Army and Air Force elements, neither of the Services needs to change its current methods of establishing SA through a COP. The speed and efficiency with which commanders receive information, apply it to battle command and operational design, and pass information to subordinates is sufficient for the current operating environment, with one caveat. Receiving quality information is contingent upon the ability of both the commander and staff to filter and process data and information effectively, which in turn requires certain levels of both training and human cognitive ability (Widder 2002, 9).

In researching the fifth secondary question, whether or not either the Army or Air Force should change its methods for gaining SA and establishing a COP, the author came to realize three issues regarding future development and employment of systems. First, Army and Air Force systems have become increasingly compatible and the interconnectivity continues to improve with the release of each new software version. Second, leader and operator proficiency must keep pace with these upgrades and modifications through both institutional and unit training programs. Finally, the road to joint interoperability goes beyond technology and requires a procedural vice commonality approach to joint interoperability.

Army and Air Force systems have become increasingly compatible and interconnectivity continues to improve with the release of each new software version (Roosevelt 2006, 7). The research revealed that any preconceived notions regarding incompatibilities between Army and Air Force graphics-oriented battlefield tracking systems are completely unfounded. The systems were indeed incompatible during the program inception in the mid-1990s and subsequent fielding of the first versions at the turn of the century (Ooms 2004, 17). Since then both Services have made, and continue to make progress towards system commonality and interoperability.

The latest software versions establish the interconnectivity, messaging standards, and SOA required for ABCS and TBMCS systems to interface successfully. This includes the aforementioned CID server interfaces that allow Link 16 and FBCB2 systems to display a common operating picture (Hinson and Summit 2009, 59). Figure 4 demonstrates how CID facilitates information sharing between Link 16 to FBCB2 feeds. The CID server polls all linked graphics-oriented battlefield tracking systems and compiles all positional data into a centralized database. Units then distribute information to different systems and platforms to create a joint interoperable and integrated common operating picture. The Army and Air Force should sustain current methods of establishing SA, but continue to improve upon the current levels of interoperability. The desired endstate should be a seamless process for establishing the required interfaces that are as transparent as possible to the user (Bledsoe 2008). A byproduct of this interconnectivity and interoperability is a reduction in the number of screens that commanders, operators, and battlespace controllers have to look at.

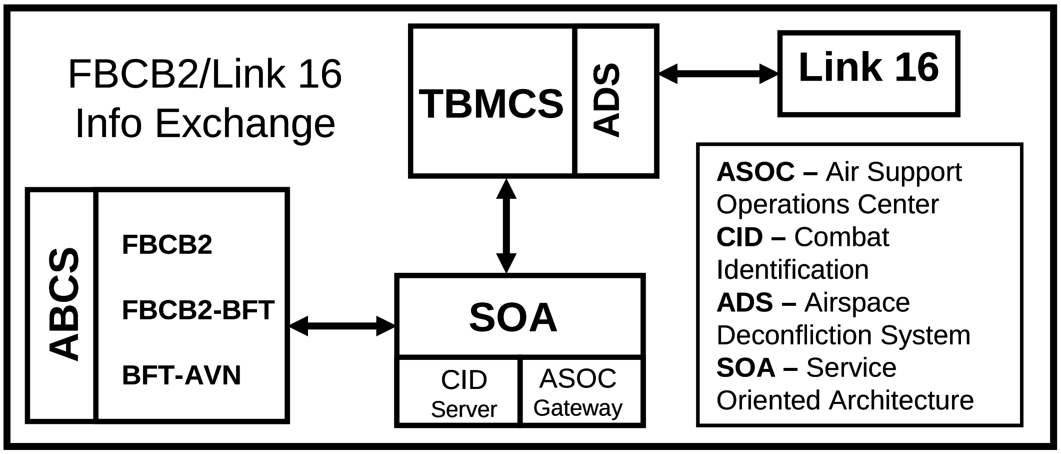

Figure 4. FBCB2-Link 16 Information Exchange
Source: Created by author based on data from Jason Hinson and Bob Summit, “Combat Identification Server: Blue Force Tracking in the Cockpit,” *A Common Perspective: The Joint Doctrine, Education, and Training Newsletter* 2, no. 2 (1st Quarter, FY 2010): 59-61.

Proficiency with such a wide variety of C4ISR systems must keep pace with system upgrades and modifications. This requires a tremendous amount of command emphasis (Doton 1996, 15). Units should train on the systems currently available, rather than waiting for future software upgrades or the development and fielding of a common, all-encompassing, and standardized system-of-systems (Spierto 1999). Institutional training programs at all Army and Air Force centers of excellence incorporating the Army Battle Command Training Strategy and Air Force Digital Education Strategy will provide the operators with the skills and leaders with the knowledge of system capabilities needed to employ the systems effectively in combat (Schultz 2010). Although C4ISR assets are important, they are only tools to facilitate organizational operating procedures (Department of Defense 2010c, I-2). Unit training fully integrates the systems into the way an organization operates during full spectrum operations. The number one

reason that units are not using equipment properly, as reported by TRADOC Capability Managers, Battle Command Training Program teams, and systems integration teams, is lack of training.

Consequently, in researching numerous incidents of fratricide and cases involving delays in CAS, CCA, or MEDEVAC for inclusion in this paper, the leading cause was also shortfalls in training that led to human error. Although many of the incompatibility issues had been resolved, leaders and operators were not aware of the improvements to the systems. The organization's level of training and proficiency on both the operation of equipment and implementation of standardized operating procedures dictated how well the processing of information supported battle command. Figure 5 depicts the difference in Air Force communications infrastructure available during Operation Iraqi Freedom compared to what was available during Operation Desert Storm. Clearly, in the twelve years between the two wars, the DOD made much progress to meet the demands for information technology capability. Achieving joint interoperability goes beyond technology. Despite the speed of transmission mediums and system capabilities for processing information, ultimately the ability to gain SA and understanding depends on the training, education, knowledge, and experience of the decision maker.

USAF C4 Infrastructure ODS vs. OIF			
System	ODS	OIF	Change
Commercial Satcom Terminals	5	34	+560%
Average Commercial Bandwidth (Mb)	7	10	+47%
Military Satcom Terminals	20	44	+120%
Average Military Bandwidth (Mb)	2	3	+68%
Terrestrial Links (aka Ground LOS)	11	30	+173%
Average Terrestrial Bandwidth (Mb)	2	10	+444%
Global Broadcasting System (Mb)	24	24	0%
Total Terminals	36	107	+167%
Total Bandwidth (Mb)	113	783	+596%

Figure 5. USAF C4 Infrastructure Operation Iraqi Freedom vs. Operation Desert Storm

Source: Created by author based on data from T. Michael Moseley, "Operation Iraqi Freedom–By the Numbers," Shaw AFB, SC: CENTAF-PSAB, 30 April 2003; US Army Command and General Staff College, O100 Advanced Sheets and Readings, *O100 Coalition Force Land Component Command (CFLCC) Operations* (Fort Leavenworth, KS: Government Printing Office, 2009), 70.

In addition to the unit commander, key players include coordinating and special staff, battle captains, battle NCOs, and operators. All of them support battle command by filtering vast amounts of data and selecting information relevant to the mission and the commander's intent. The ability to do so has sustained the battle command process throughout two major operations, simultaneously. Even today, the available C4ISR systems are able to support battle command with limited physical, or hardwired, interconnectivity. Over the past nine years, units achieved logical connectivity between

platforms through effective systems integration where the battle captains, battle NCOs, and operators managing the systems provided the common link between systems.

Thoughtware vs. Standardization

As the military moves towards standardizing C4ISR technology, it is replacing the human dimension of system commonality with software and hardware interfaces. It is even more important to have competent personnel able to process shared information logically. Enhanced information technology, bandwidth, and processing speed over the past century have boosted the amount of information flowing freely across the operating environment. Desert Storm's vast and dynamic battlespace required commanders to traverse the battlefield continuously, traveling from command post to command post in order to gain better SA and SU. Although Mobile Subscriber Equipment provided voice and limited data support at the halt, commanders executed the majority of communications via short-burst radio messages, while sending longer messages using satellite phones (McGrath 2006, 219).

At the same time, organizational leaders were beginning to understand the value of using computer graphics to depict the tactical and operational situation so that the higher-level decision makers could understand what forces they had to work with at any given moment. General Frederick Franks, 3rd Army Commander, soon discovered that the success or failure of a briefing to General Norman Schwarzkopf, the Central Command Commander, depended on the clarity of the display of information (Swain 1997, 105). This in turn created a demand for the ability to transmit these types of graphics to all commanders simultaneously, a feat that proved untenable with the 16kbs

of bandwidth provided by Mobile Subscriber Equipment along with extensive unreliability.

As with any type of automation, C4ISR systems are supposed to provide timesaving tools and solutions for dealing with complex problems. However, if the additional time is now being spent receiving, processing, and analyzing information when the majority of it is untimely, redundant, or irrelevant, then the extra time gained is immediately wasted. Commanders will perceive the new information technology as a major drawback, rather than embracing it as a combat multiplier. Figure 6 shows how advances in technology have exponentially increased the amount of information being processed on the battlefield (Findley and Luck 2008, 8). In less than a century, the military has gone from field telephones to high-speed tactical internets. Transmitting data across the operational environment is no longer a problem (Widder 2002, 9). Instead, the new challenges lie in the processing of vast amounts of information in support of battle command.

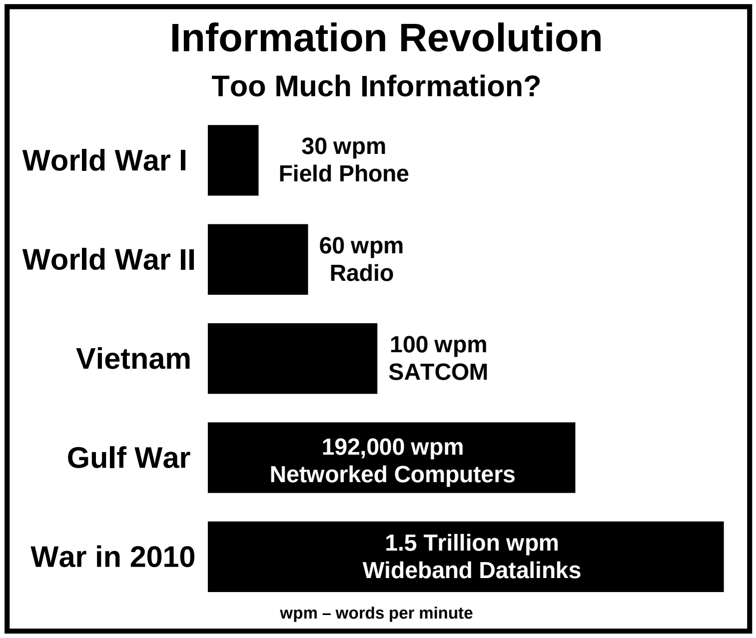

Figure 6. Information Revolution
Source: Created by author based on data from Mike Findley and Gary Luck, *Joint Operations: Insights and Best Practices*, 2nd ed. (Norfolk, VA: USJFCOM, July 2008), 8.

The amount of information can surpass the ability of the commanders and staff officers to manage, fully understand, and react in a timely and efficient manner (Department of the Army 2008a, 5-2). An even greater risk is the potential for overlooking vital information in the sheer volume of data transmitted (Findley and Luck 2008). Finally, not all units have the same human ability or technological capacity to send, receive, and understand data. In addition to diverse capabilities, smaller tactical units lack the capacity for processing the same amount of data as the higher headquarters (Wass de Czege 2010, 26).

Two schools of thought dominate the approach to contending with information overload. The commonality approach favors the standardization of systems as a means of

eliminating as much training and operating friction as possible. Meanwhile, the procedural approach focuses more on systems integration and developing methods for processing information.

In the *Encyclopedia of Computer Science and Technology* Dr. Victor H. Yngve advocated the need for commonality in systems between Service components (Yngve 2000, 175). According to a 2010 *Defense Daily* article on the Army and Air Force UAS programs, it would appear that the military is heading in this direction (Roosevelt 2006, 2). Interoperability through platform commonality has become the focal point of much effort between the Army and Air Force. Standardized systems such as the UAS and OSVRT are beginning to appear more frequently among the Services. Colonel Christopher Carlisle, Director of the Army UAS Center of Excellence at Fort Rucker, Alabama, recently stated in an *Army Times* article, "the commonality of systems and open architecture is not only required, but it's demanded for any new equipment" (Brannen 2010a, 27).

This statement alludes to a strong argument regarding future C4ISR programs that John Garing, the Defense Information Systems Agency Director for Strategic Planning refers to as the "efficiency imperative" (Gallagher 2009). The efficiency imperative highlights the importance of reducing costs and overhead for systems by moving to a shared, standard system for common services. The efficiency imperative is not without merit. Despite being the next-generation, shared, standardized system for common communications services, Net Enabled Command Capability failed to meet the imperative of reducing costs and overhead (Gallagher 2009). Inter-Service haggling over capability requirements, shifting demands, and funding setbacks compounded the

situation resulting in the program's cancellation. It would appear that a viable solution to realizing joint interoperability through system commonality is not easily achievable.

The counterpoint to system commonality is also the current solution to bridging the gaps in joint interoperability. The authors of *Planning and Architectural Design of Modern Command Control Communications and Information Systems,* a book written in 1997 (Evrendilek et al. 1997, 183), offer that an assortment of systems logically integrated into the C2 construct of the organization that are acceptable. Instead of having the same systems everywhere, the authors maintain that the effective interaction of two primary functions, data fusion and decision support, is more important than standardization of technology.

In a March-April 2010 *Military Review* article, retired Brigadier General Huba Wass de Czege, the founder and inaugural director of the School for Advanced Military Studies located at Fort Leavenworth, Kansas, cautions leaders regarding the pitfalls of becoming overly dependent on networks (Wass de Czege 2010, 26). Specifically, units tend to overemphasize information technology acquisition as the primary means to become a "network-centric" organization. In doing so, the tendency is to ignore the relationship between the information and combat power. The fact is that systems integration rather than acquisition has been the method for achieving interoperability since the first telegraph was set up in 1844 and used by Lincoln to issue strategic orders to Grant (Wass de Czege 2010, 21).

Recalling the thoughtware model introduced earlier in this chapter (Stephenson 2006), the same concept can be applied to operational and tactical communications systems, albeit on a smaller level (see figure 3). Substituting "resources" with "combat

power," and then exchanging "combat power" with "technology" to the right of the triangle, one can easily see how thoughtware links the two. The desire for more effective and lethal combat power drives the need for better technology. Once acquired, thoughtware enables the new technology to enhance combat power.

No amount or level of complex technology on its own can contribute to mission success. An organization's technology, or network, is not merely a conduit for information; it allows the sharing of SA among the commanders and across the battlefield. The commander then internalizes the information and, through careful analysis and synthesis, gains SA and SU (Department of the Army 2010b). Both SA and SU allow the commander to exercise Battle Command, making sound decisions on the best way to employ combat power, which in turn feeds information such as slant reports, maintenance statistics, and enemy locations back to the commander via the available technology. From a maneuver perspective, information superiority requires superior information collection, processing, and dissemination to achieve enhanced C2 and precise knowledge of friendly locations (Department of Defense 2010c, II-2).

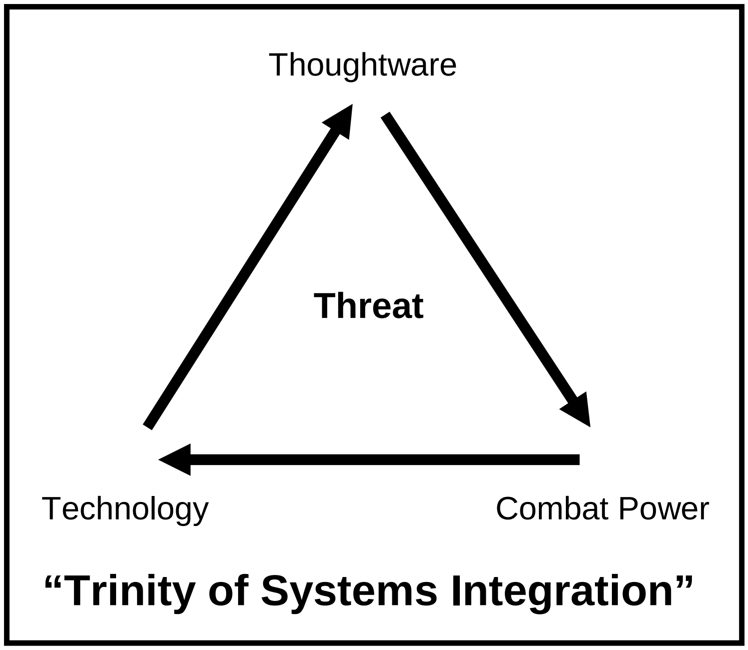

Figure 7. Trinity of Systems Integration
Source: Created by author.

Regardless of the type of technology employed, whether common, interoperable, or completely separate, people are still needed to apply the thoughtware. These people are the operators, Battle Captains, and Battle NCOs working in the tactical operations centers and main command posts. It follows then that the right combination of multiple platforms orchestrated and operated by the right people is acceptable. In fact, joint doctrine suggests that a well-crafted, coordinated set of integrated and interoperable procedures is more important than having a preponderance of information systems. “Without a professional force to leverage the value of technology, organization, and strategy, all three are diminished” (Department of Defense 2010c, I-2).

The latest Army Capstone Concept validates the importance of a professional force even further (TRADOC 2009). Operating under conditions of uncertainty and

complexity in an era of persistent conflict requires adaptable information technology. These types of operations also require adaptable leaders to leverage that technology and overcome the limits of communications systems. As vast and robust as available systems are, there are still limitations caused by a lack of interoperability, capacity, and human capability.

From an interoperability standpoint, U.S. military actions are always a multinational effort. Operations in Iraq, Bosnia, Kosovo, and Afghanistan required the alliances and partnerships of international coalitions. Unfortunately, poor interoperability has denied these coalitions adequate SA through a multinational common operating picture. The majority of documented fratricide incidents thus far in Operations Enduring Freedom and Iraqi Freedom have involved military units of different nations. The shoot down of the RAF Tornado Fighter Jet by a U.S. Patriot Missile over Ali Al Salem Airbase, Kuwait in 2003; the 2002 bombing of Canadian Soldiers by an American F-16 Fighter Jet near Kandahar, Afghanistan; and a 2006 bombing of British Royal Commandos in Helmand Province, Afghanistan by a U.S. F/A18C Fighter Jet are examples of incidents for which C2 communications systems are an effective countermeasure.

Current and future operations will require leaders to operate in a degraded mode that matches the information technology capabilities of the host nation and coalition partners. Nine years of continuous combat and counterinsurgency operations have also highlighted the need for a whole-of-government approach to overseas contingency operations. Synchronizing DOD activities with those of other government agencies, intergovernmental organizations, and non-governmental organizations is paramount to

winning at the strategic level. As interagency and intergovernmental interdependence becomes the standard, the requirements for interoperable communications are becoming more apparent. Successful information sharing requires equal access to systems, tools, and bandwidth for all military and civilian agencies.

The new Army Capstone Concept also points out shortfalls in information technology capability. Current systems are not capable of depicting all types of threat or passing all forms of information needed for SA and understanding. The uncertainty and diverse nature of social, cultural, and political factors that exist where armed conflicts occur cannot be easily translated into a map overlay or briefing slide (TRADOC 2009). Intangibles such as enemy competence, morale, cohesion, and motivation are impossible to capture graphically. Instead of technology, military leaders should renew focus on understanding the dynamic and complex human, cultural, and political environment. These requirements are often lost in the pursuit of acquiring the latest information technology innovations. Operation Eagle Claw, the failed joint mission rescue hostages in Iran is an example of failure to collaborate at the joint level. Although an extreme example of how such failure can lead to disaster compared to the current topic of joint interoperability of communication systems, one parallel can be drawn. In the official accident report, investigators concluded that the leaders and operators involved mistook "enthusiasm for capability" (Kamps 2006). In relation to information technology, leaders and information technology professionals become overly focused on acquiring the right types of systems that the mistake enthusiasm for necessity.

Capacity shortfalls identified in the document have less to do with technology than with the people operating the technology and making decisions based on the

information being sent and received. TRADOC PAM 523-3-0 points out that "human cognition" is limited (TRADOC 2009). Going back to the importance of systems integration discussed earlier in this chapter, the ability to apply information technology is more important than the technology itself. Although the right information technology can answer the questions, "Where am I? Where are other friendly elements? Where are the enemy elements?" it takes competent and innovative leaders to ask and answer, "Who else needs to know?" and "What are we doing about it?"

To answer the last secondary question, although neither Service should change its method of gaining SA and SU or developing a COP, commanders should understand the role of information technology in a network centric organization. Commanders should consider the difference between pursuing system commonality and developing proficiency in systems integration when developing standard operating procedures, techniques, tactics and procedures, and unit training programs.

Design Considerations for Future Systems

From the research conducted, the author concluded that different graphics-oriented battlefield tracking systems, as employed by the Army and the Air Force at the operational and tactical levels in full spectrum operations do not have a negative impact on joint SA. There are, however, several design, development, and employment considerations for future systems. Future systems should be scalable to allow for expansion of both capability and capacity. Yet, the systems should not be overly complex as to prevent or deter users from employing them. Both the acquisition process and application of the systems should involve a high degree of thoughtware (Stephenson

2006). Finally, leaders should implement training on system operation and integration throughout.

Future systems should always be designed to support battle command (Department of the Army 2008a, 5-2) based on interoperability, compatibility, and supportability requirements (Department of Defense 2010c, II-15). Rather than focusing on information sharing as a means of supporting C2, the system should support well-crafted and coordinated sets of integrated and interoperable procedures (Department of Defense 2010c, III-21). In the near future, systems must continue to be scalable and allow for expansion of both capability and capacity (Department of the Air Force 2006b). Systems should be hybrid and versatile. New technology will allow commanders to exercise C2 effectively in the new type of combined arms warfare where air-ground integration has become increasingly prevalent while the occurrences of fratricide and collateral damage have become more frequent (Vessey 2010, 14).

Joint doctrine acknowledges that technological superiority does not equate to information and decision superiority (Department of Defense 2010c, III-21). A lack of collaborative capabilities can result in severe operational limitations. The goal should be a leader-centric system as opposed to network-centric. The Army and Air Force must maintain the ability to transition quickly between major combat operations, irregular warfare, stability operations, humanitarian assistance missions, and beyond. Therefore, systems that are versatile and flexible without being overly complex are essential.

System complexity can prevent or deter users from employing them. What a software designer or technician can do with the software program in a Silicon Valley lab may not work for an operator in a tent in the desert with only forty hours of new

equipment training (Wass de Czege 2010, 31). Attempting to incorporate every single type and scope of information technology available into a single system is unnecessary and creates a counterproductive environment of information overload (Findley and Luck 2008, 8). Additionally, advances in technology, while making the sharing and flow of information easier, have also created new challenges for planning and combat assessment. Since technology has enabled the use of precision munitions and better intelligence gathering, leaders have a greater responsibility to take every measure to avoid collateral damage, especially civilian casualties. Second and third order effects of bombing campaigns, indirect fire and CAS missions must now be carefully considered as opposed to the so-called "carpet bombing" campaigns of the past where the absence of advanced weaponry made high levels of collateral damage acceptable (United States Joint Forces Command 2010).

The same advances meant to enhance the tactical effectiveness of our combat power, such as UAS and Apache equipped video feeds, also work against STRATCOM efforts as pointed out by Colonel Drew R. Meyerowich in a monograph titled, "Typewriter Leadership in a Facebook World" (Meyerowich 2009). Even an object as simple and low-tech as a handheld digital camera can have worldwide negative impacts. The digital photos released of prisoner abuse in Abu Ghraib Prison in Iraq are a testament to this. Videos and pictures of combat released to the world have serious implications.

In reviewing collateral damage incidents for relevant case studies, the author considered the 12 July 2007, video of an Apache helicopter killing eleven people, including two Reuter's news employees, and wounding two children in New Baghdad, Iraq (Hodge 2010). Although a classified and encrypted video feed, Wikileaks.com was

able to obtain and break the encryption on the footage (Youtube.com 2007). In addition to the video, the words of the pilots portray a nonchalant attitude towards both the people recently killed and the two wounded children. Although military personnel may be somewhat desensitized to this type of banter, the vast majority of the world is uninitiated to combat situations and may find the pilots' words particularly horrifying. The video also points out a HUMVEE purposely driving over a dead body as Soldiers arrive at the scene of the incident.

The pilots, the Soldiers that arrived at the scene, along with all other Servicemembers, must now be prepared to have words and deeds in a combat situation scrutinized by the entire world. However, this is the nature of the information revolution and implications of taking digital photographs of everything and video taping combat engagements. In addition to added responsibility during targeting, every Servicemember now must be cognizant of statements and actions if the military continues to use the video and digital photography in the current fashion.

Unit training requirements, predeployment preparation, personnel turnover and redeployment tasks place a high demand on limited time and resources (AFMCTT CENTCOM 2008). Contending with complicated and highly technical new equipment fielding or intricate software upgrades places undue pressure on an organization and its leaders. At a minimum, joint fires systems and networks should incorporate real-time receipt, display, and screening of tactical imagery and video screens (Bledsoe 2008). The capacity for multi-service, interagency, and multinational information management, data correlation, and display at multiple security levels is an absolute must.

Leaders should apply a high degree of thoughtware to the acquisition and application processes for new technology (Stephenson 2006). Program managers should factor in support and training costs while making every effort to avoid duplication of effort and stovepipes. However, program managers are only partly responsible in the acquisition process. Collaboration between highly competitive system developers and military contractors must take place. The DOD should persuade industry leaders in the development of C4ISR systems such as General Dynamics Corporation, L-3 Communications Corporation, and Northrop Grumman Corporations to work together when developing the joint systems of the future (Defense Update 2009b). With the new method of waging combined arms warfare, where increased interdependence between Air Force and Army combat power is the norm, joint interoperability equals maximum effectiveness (Comanor et al. 2009, 76).

Another consideration is that sometimes, less is more. For example, satellite coverage in the mountains of Northern Afghanistan can be extremely spotty, making it untenable for commanders and operators to stop and upload or download intelligence updates and other information (Matthews 2008). Moreover, after nine years in Afghanistan and seven years in Iraq, many organizations have become accustomed to assuming the established and mature power generation and communications infrastructure already available in theater. Leaders and communications professionals have set aside the lessons learned from the early weeks and months of Operations Enduring and Iraqi Freedom where units contended with unreliable power generation, limited internet connectivity, and low bandwidth.

In reality, these conditions will likely exist in the next irregular war or major combat operation. The supported number of systems in a typical tactical operations center further complicates the situation. The amount of transit cases for computer and networking hardware, power generators, peripherals, and other equipment runs counter to the requirements of a Brigade Combat Team as an expeditionary force. Possible options for data exchange strategies include compression technology, data schema, and event-based server pushes to reduce traffic (Matthews 2008). Adapting new industry standards such as the National Imagery Transmission format 2.1 used throughout the intelligence community for imagery and related products is optimum for low bandwidth and limited storage (Wright 2010, 5).

The old saying that "information is power" may no longer apply to military operations (Wass de Czege 2010, 21). Files with excessive data or that are too large to be easily transmitted are counterproductive, needlessly tax available bandwidth, and take too much time to process. Consider how the air and space operations center can transmit a typical retasking order for an F-16 fighter to the pilot in one or two lines of text via Microsoft Internet Relay Chat (Department of the Air Force 2006a). The Air Force condenses the same amount of information that is normally contained in a multi-megabyte slide presentation into a simple message sent over a low bandwidth network via a simple messaging software platform.

Finally, the DOD should implement training on the system operation and integration throughout. Dissemination of SA data and targeting information across platforms and joint systems through extensive communications interfaces requires a high degree of training and proficiency with a multitude of systems and processes (Bledsoe

2008). In addition to systems integration, operators must also become familiar with the unique language and procedures of both the Army and Air Force. Army and Air Force ground and air assets should be fully integrated to overcome the complexities of war, adapting the Army and Marine Corps methods of briefing the air scheme and ground scheme using common graphics (Jin and Patterson 2010, 4).

Joint interoperability means moving beyond just the current method of determining and passing air power apportionment to the Joint Forces Land Component Command Commander or embedding ad hoc organizations such as the Battlefield Coordination Detachment with the Joint Forces Air Component Command and an Air Liaison Officer cell with the Joint Forces Land Component Command (Department of Defense 2007d). Joint training and experience should start earlier on in the careers of both Soldiers and Airmen in order to develop a better understanding of each other's Service. The new Battle Command Training Strategy addresses many of these issues and concerns. The key to successful implementation of that strategy lies in increasing awareness through training and command emphasis. Doing so will promote interdependence and interoperability by breaking down the barriers created by decades of interservice rivalry and differences in organizational culture.

Conclusion

The Army and Air Force based their acquisition of C4ISR systems on similar demands and needs. Development of both the TBMCS and ABCS programs serve the same basic purpose under the same operational concepts (Biever and Wass de Czege 1998, 16). The existing variety of graphics-oriented battlefield tracking systems is a product of shortfalls in the acquisition process and organizational culture. Both Services

went about the acquisition process based on the acceptable methods and best practices of 1995. More than a decade later, the Services are still finding it hard to make the paradigm shift from unilateral acquisition to one of collaboration.

The challenges to developing and achieving a truly joint system for both the Army and Air Force stem from a combination of organizational culture and shortfalls in training. Interservice rivalry, organizational culture, loopholes in the acquisition process, and budget limitations have resulted in a wide variety of C4ISR systems fielded. Shortfalls in training on these systems, either on-the-job or institutionally, prevents collaboration and keeps Servicemembers from gaining the knowledge and proficiency to make the systems work together. The research conducted revealed no evidence that any incidents of fratricide, collateral damage, or delays in the arrival of air support were caused by either system interoperability or having too many different systems.

Although neither Service should change it method of gaining SA and SU or developing a COP, commanders should understand the role of information technology in a network centric organization. Additionally, leaders should consider the difference between pursuing system commonality and developing proficiency in systems integration. Different graphics-oriented battlefield tracking systems, as employed by the Army and the Air Force at the operational and tactical levels in full spectrum operations do not have a negative impact on joint SA. There are, however, several design, development, and employment considerations for future systems. Future systems should be scalable to allow for expansion of both capability and capacity. Yet, the systems should not be overly complex as to prevent or deter users from employing them. Both the

acquisition process and application of the systems should involve a high degree of thoughtware (Stephenson 2006).

CHAPTER 5

RECOMMENDATIONS AND CONCLUSION

Military communications professionals and leaders in both the Army and Air Force have serious misconceptions regarding the interoperability of Army and Air Force graphics-oriented battlefield tracking systems. Recent operations in Iraq and Afghanistan have demonstrated two things. First, current Army and Air Force C4ISR systems support battle command and are completely interoperable. Second, there are serious institutional and operational training shortfalls. This prevents the efficient employment of these systems and continues to foster an organizational culture of interservice rivalry that runs counter to achieving joint interdependence.

The case studies from Iraq and Afghanistan do not provide specific lessons or answers. The cases examined demonstrate that having a variety of different systems does not impede joint operations between the Army and Air Force. Instead, human error, training shortfalls, and environmental conditions are the primary causes of fratricide, collateral damage, and delays in the arrival of support. Nevertheless, the identified training and acquisition problems do provide important lessons for the way ahead. The recommendations presented in chapter 5 are applicable when developing and acquiring future graphics-oriented battlefield tracking systems capable of meeting the needs of joint interoperability.

Interpretation of Findings

From the analysis conducted in chapter 4, the author reached six conclusions regarding joint interoperability of graphics-oriented battlefield tracking systems. First, the

DOD developed the ABCS and TBMCS systems to meet similar needs and demands. Second, the reason for the different graphics-oriented battlefield tracking systems employed by the Army and Air Force is due to a combination of acquisition process shortfalls and organizational culture. Third, the challenges to developing and achieving a truly joint system for both the Army and Air Force stem from a combination of organizational culture and shortfalls in training. Fourth, the case studies examined contained no evidence that a lack of system interoperability or the use of too many different systems caused the incidents. Fifth, neither of the Services needs to change its current methods of establishing SA through a COP. Finally, different graphics-oriented battlefield tracking systems, as employed by the Army and the Air Force at the operational and tactical levels in full spectrum operations do not have a negative impact on joint SA.

Similar needs and demands drove the acquisition processes for ABCS and TBMCS. Other than the mission-specific nature of the individual elements, both programs are fundamentally and conceptually the same. Although the technical specifications and level of complexity needed to meet Army and Air Force requirements differ, the essential goals of each program are to leverage information technology for battle command, enhancing SA and understanding through information superiority. As previously stated, recent upgrades including Publish and Subscribe Service, SOA, and CID server software, have bridged the gap between systems as needed to achieve joint interoperability. The Army and Air Force could have collaborated to develop and procure a common suite of systems under that same program. However, the reason the two

Services did not collaborate was due to the stovepipe nature of the acquisition process, military culture, and interservice rivalry existing at the time.

The combination of acquisition process shortfalls and organizational culture resulted in the mixture of graphics-oriented battlefield tracking systems employed by the Army and Air Force. When the Secretary of Defense charged the Services with developing a C4ISR system capable of achieving information superiority in 1995, the climate of interservice rivalry and competitive budgets led to the separate program developments. However, despite a flawed acquisition process, the Services had no problem acquiring systems. Both the Army and Air Force have a great deal of information technology systems at their disposal. More than ten years after fielding the TBMCS and ABCS systems, the Services are still struggling with the paradigm shift. The efforts and actions of senior military executives are making Army and Air Force leaders more aware of the time, taxpayer dollars, and effort wasted during the current military acquisition process. Consequently, the Services are slowly moving from a unilateral acquisition process to one of collaboration and cooperation between branches. The challenge is to overcome the incompatibilities in existing systems and avoid future stovepipe acquisitions and duplication of effort.

The challenges to developing and achieving a truly joint system for both the Army and Air Force stem from a combination of organizational culture and shortfalls in training. The wide variety of C4ISR systems fielded is due to interservice rivalry, organizational culture, loopholes in the acquisition process, and budget limitations. As explained in chapter 4, the Army and Air Force are making progress in overcoming these conditions, but it will take considerable time and effort. The Army and Air Force are

continuing to work on bringing those systems to an acceptable level of joint interoperability. Both Services can take steps in the short-term, however, to make the current systems more effective. Shortfalls in unit and institutional training programs are preventing collaboration and keeps Servicemembers from gaining the knowledge and proficiency to make the systems work together. Refocusing training priorities will require greater command emphasis. It is the only way for leaders and operators to improve their knowledge and familiarity with systems.

From the analysis of the three cases, the study revealed no evidence that system interoperability issues or the number and type of different systems caused any of the incidents. Terrain and weather caused the delayed arrival of CAS and CCA at Combat Outpost Keating. Human error, mechanical failure, and training shortfalls contributed to the incident of fratricide involving the RAF Tornado. Despite the unfortunate incident of collateral damage in Azizibad, CAS was on station and on time to engage the target as requested by the Special Operations Forces and Afghan Commandos on the ground. All three cases revealed that the equipment available to Army and Air Force units are effective if properly employed.

Therefore, neither of the Services needs to change its current methods of establishing SA through a COP. Commanders send and receive information with speed and efficiency. The systems available facilitate battle command and operational design. Commanders sufficiently pass information to subordinates in a variety of operating environments and varying situations. One area of concern that emerged was information overload and the ability to filter and process data and information effectively. The two best methods for avoiding information overload are the commonality and procedural

approach. The commonality approach favors the standardization of systems as a means of eliminating as much training and operating friction as possible. Meanwhile, the procedural approach focuses more on systems integration and developing methods for processing information.

The author concluded that different graphics-oriented battlefield tracking systems, as employed by the Army and the Air Force at the operational and tactical levels in full spectrum operations do not have a negative impact on joint SA. In addition to joint interoperability, future systems should be expandable and scalable to allow for expansion of both capability and capacity. System developers and program managers should avoid making future systems overly complex. Making the installation, operation and maintenance of software programs and applications deters users from employing them or learning to use them. In addition to long-term support and maintenance considerations, program managers must consider training on system operation and integration throughout.

Recommended Changes

Based on the analysis of history, challenges, and emerging technology involved with graphics-oriented battlefield tracking systems, both programs require training and acquisition modifications. First, leaders and operators need more training on systems operations, management, and integration. Second, the DOD needs to reform and simplify the acquisition process to make it more efficient. These two conclusions and the recommendations that follow have important implications for the future joint operating environment.

There were two unexpected findings from the research. First, ABCS and TBMCS are fully interoperable. This includes the graphics-oriented battlefield tracking systems, Link 16 and FBCB2, via new SOA. Users lack both the training required to configure and operate the systems and the familiarity with the ever-expanding menu of capabilities and features. Another unexpected finding was that many leaders and operators are equally unaware of similar capabilities in their own Service's programs. For example, instances of tactical operations centers not using certain ABCS systems simultaneously were due to a lack of technical knowledge. For example, using the Publish and Subscribe Service feature of ABCS, operators can track FBCB2 and Advanced Field Artillery Tactical Data System symbology at the same time, and on the same workstation. Both the Army and Air Force need to place greater emphasis on training.

Acquisition reform is required. The Performance-Based Logistics process is the best option in terms of system maintenance support and quality, but the acquisition process itself requires drastic changes. DOD should streamline the process and make it easier to get approval for new technology. However, the new technology sought after must meet mandatory criteria for joint interoperability, scalability, and expandability. Simply put, the process should make it impossible to buy the wrong type of equipment while making it easier to buy the right type of equipment. Program managers must make every effort to avoid duplication of effort and stovepipes. A crucial part of this is better collaboration among C4ISR industry leaders such as General Dynamics Corporation, L-3 Communications Corporation, and Northrop Grumman Corporation.

Battle command remains the foundation for interoperability, compatibility, and supportability requirements of future systems. Sharing information is important, but a

well-crafted and coordinated set of integrated and interoperable procedures allows the sharing of SA and development of a COP. System complexity can prevent or deter users from employing them. What a software designer or technician can do with the software program in a lab may not work for an operator in a tent in the desert with only 40 hours or less of new equipment training. Attempting to incorporate every single type and scope of information technology available into a single system is unnecessary and creates a counterproductive environment of information overload.

After nine years in Afghanistan and seven years in Iraq, many organizations have become accustomed to mature power generation and communications infrastructure. The amount of transit cases for computer and networking hardware, power generators, peripherals, and other equipment found in a typical tactical operations center runs counter to the concept of a Brigade Combat Team as an expeditionary force. Communications field craft and the lessons learned from the early weeks and months of Operations Enduring and Iraqi Freedom contending with unreliable power generation, limited internet connectivity, and low bandwidth have been set aside. These conditions will exist in the next irregular war or major combat operation.

Files with excessive data or that are too large to be easily transmitted are counterproductive, needlessly tax available bandwidth, and take time to process. Possible options for data exchange strategies include compression technology, data schema, and event-based server pushes to reduce traffic. Adapting new industry standards such as the National Imagery Transmission format 2.1 used throughout the intelligence community for imagery and related products is optimum for low bandwidth and limited storage.

Most importantly, C4ISR systems and networks should continue to incorporate joint interoperability, real-time receipt, display, and screening of tactical imagery and video. Additionally, leaders are placing greater emphasis on a whole-of-government approach to overseas contingency operations. This is in addition to the current push for better joint and multinational interoperability and interdependence. All approaches require additional capacity for interagency, intergovernmental, and multinational information management, data correlation, and display at multiple security levels.

There are significant implications for the future joint operating environment. Systems should be hybrid, agile, and versatile. New technology will allow commanders to exercise C2 effectively in the new type of combined arms warfare where air-ground integration is the new norm. Joint doctrine acknowledges that technological superiority does not equate to information and decision superiority. A lack of collaborative capabilities can result in severe operational limitations for the joint force. The Army and Air Force must maintain the collaborative capabilities necessary to transition quickly between major combat operations, irregular warfare, stability operations, humanitarian assistance missions, and beyond. Therefore, systems that are versatile and flexible without being overly complex are essential.

Additionally, advances in technology enabled the use of precision munitions and better intelligence gathering. Planners must take every measure to avoid collateral damage, especially civilian casualties, during the planning process. Units have to consider the second and third order effects while carefully executing indirect fire, air interdiction campaigns, and reactionary missions against targets of opportunity.

One recommendation derived from both the Abu Ghraib Prisoner Abuse incident in 2004 and the New Baghdad, Iraq, collateral damage incident in 2007. In both cases, the use of information technology resulted in severe strategic communications setbacks for the U.S. national security interests and the military efforts in Iraq. Commanders reexamine requirements for using digital video and photography equipment and set stricter guidelines for their use. There was no excuse for the presence of a digital camera or the digital photographs taken at Abu Ghraib Prison. In the New Baghdad incident, the camera mounted on the Apache helicopter was obviously for reconnaissance purposes. However, the reasons for recording this type of video are unclear, beyond the possible advantages of better identifying and clearing targets. The video pod failed to assist in the prevention of collateral damage during the application of reactionary fires on a target of opportunity. The pilots incorrectly identified cameras and camera bags as weapons and did not see two children sitting in the front seat of the van through an open passenger window. As with any other weapon system or piece of military hardware, if the equipment is not providing some type of tactical advantage, then it should not be used.

Joint interoperability means moving beyond just the current method of determining and passing air power apportionment to the Joint Forces Land Component Commander or embedding ad hoc organizations such as the Battlefield Coordination Detachment with the Joint Forces Air Component Commander and an Air Liaison Officer cell with the Joint Forces Land Component Commander. Joint training and experience should start earlier on in the careers of both Soldiers and Airmen in order to develop a better understanding of each other's Service. Doing so will promote interdependence and

interoperability by breaking down the barriers created by decades of interservice rivalry and differences in organizational culture.

These recommendations suggest ways to improve both joint interoperability and C4ISR systems overall. There are many benefits to procuring, developing and implementing new technology. However, leaders must also consider the risk of information overload and lack of time and resources available to gain the needed levels of proficiency. To achieve maximum effectiveness as a network-centric organization requires maximum proficiency with the networking systems available. Leaders and operators need significantly more training on systems operations, management, and integration. Reforming the acquisition process and simplifying the systems fielded to combat units will help to promote efficiency. The views offered by the author provide recommendations for the future joint operating environment.

Recommendations for Further Study

The research and analysis process for this study highlighted three areas requiring further study. First, interagency interoperability is increasingly important based on the whole-of-government approach to overseas contingency operations. As interagency and intergovernmental interdependence becomes the standard, the requirements for interoperable communications are becoming more apparent. Every overseas operation must be a multinational effort. Operations in Iraq, Bosnia, Kosovo, and Afghanistan have all required the cooperation and collaboration of international coalitions.

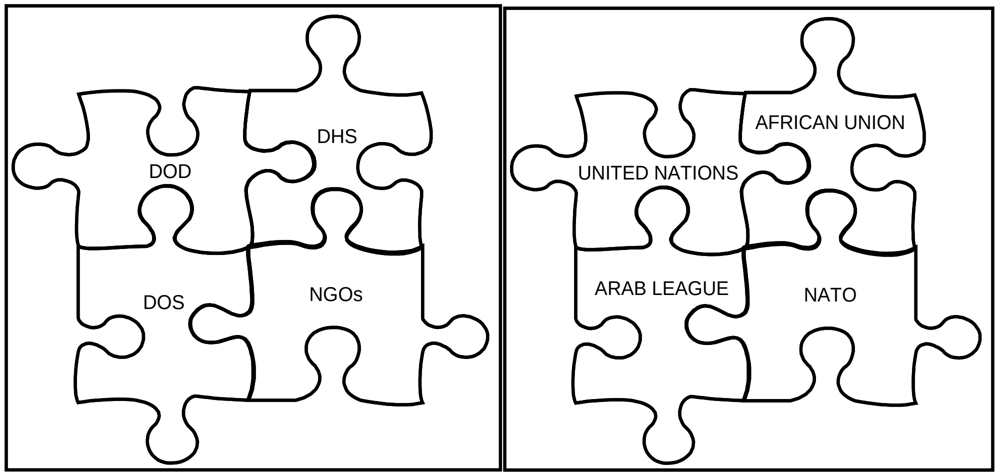

Figure 8. Interagency and Intergovernmental Interoperability
Source: Created by author.

As with interagency considerations, multinational communications require better integration and interoperability. In conducting the case study analysis in chapter 4, the majority of documented incidents of fratricide involved elements of two or more nations. Ongoing projects such as the Combined Enterprise Regional Information Exchange System, radio encryption, and NATO interfaces merit further research. Furthermore, the Army Capstone Concept for 2016–2028 discusses how being able to operate in a degraded mode that integrates allies with less technological capability is paramount to successful multinational operations. Studying these areas will definitely expand the researcher's level of knowledge and experience regarding acquisition, training, and the communications capabilities of other agencies and nations. Such an endeavor would take the study of interoperability well beyond the scope of this paper.

A final topic warranting further review is the reemerging focus on acquiring and employing airship technology. A recent article in *Army Times* reported that the DOD is procuring several airships and will be fielding them over the next ten years. The

technology can overcome inadequate satellite coverage or limitations caused by terrain in mountainous or urban operating environments. The implications for surveillance, reconnaissance, and retransmission of communications are extensive. The literature available is adequate to facilitate the research. The RAND Corporation has conducted an extensive study in addition to a wealth of documents covering the historical use of the airship, the latest research and development, and current acquisition initiatives.

Conclusion

The DOD is on the precipice of a revolution in military affairs requiring unconditional proof of joint interoperability as a prerequisite for the acquisition of information technology. Military necessity, budget constraints and the obvious benefits of joint interdependence compel the Services to collaborate more and more. Joint training exercises, joint weapons systems, joint installations are all being directed with great difficulty in an effort to change the DOD's conceptual framework. Each represents a separate revolution in military affairs. However, vast social and political changes are required both internal and external to the DOD, before a military revolution can occur where the dividing lines of money, interservice rivalry, and cultural separation between the Services no longer exist.

As the U.S. Armed Forces draw down in Iraq and Afghanistan, the nation enters into an interwar period of familiar budget cuts, social and political advocacy for avoiding future protracted wars, and closer scrutiny of required military capability. There is a real danger of falling back into the previous patterns of stovepipe acquisition, competing over defense budget allocations, and divisive interservice rivalries. The policies and direction that political and military leaders set over the next fifteen to twenty years will determine

if the gains towards joint interdependence and interoperability between the Army and Air Force made over the last nine years, and paid for in blood by America's sons and daughters, are sustainable.

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